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RESEARCH IN MEDICINE[1]

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III. Pasteur and the Era of Bacteriology

THE story of bacteriology can best be told by recounting the labors of Pasteur, for while bacteria were known and theories of infection had been elaborated and vaccination practised before his time, it was he who definitely established the importance of bacteria in putrefaction, fermentation and disease, and gave to vaccination a scientific basis. The influence of these labors is compatible in medicine only to that of Virchow in his field and is as great as that exerted in general biology by Darwin's researches. The story of rapid sequence of Pasteur's brilliant discoveries in science, each of crucial importance and establishing a new principle have, I believe, no parallel in biology or, for that matter, any other science.

But before presenting Pasteur's labors it is necessary to outline the knowledge of bacteria and the theories of fermentation, infection and allied processes which were current at the beginning of his era.

Bacteria were first seen by Leeuwenhoek, a Dutch lens-maker in 1673. This was long before the day of the compound microscope, but Leeuwenhoek was able to make such excellent short focus single lenses that he could study red blood corpuscles and spermatozoa, detect minute globular particles in yeast, and, as we know from his drawings, even discover some of the larger microorganisms in the tartar of the teeth, in saliva and intestinal and other fluids. In 1838, about the time of the development of the compound microscope, Ehrenberg attempted a classification of bacteria based on sixteen species. Our exact knowledge, however, begins with Cohn's studies which extended from 1853 to 1875, and were the first to differentiate between the spherical forms

[1] The Hitchcock lectures, delivered at the University of California, January 23–26, 1912.

which we call cocci, and the rod-like forms or bacilli. These early studies were almost exclusively botanical in nature and it was not until 1872 that Cohn could include definite disease-producing bacteria in his classification of the vegetable microorganisms.

Bacilli had been found, it is true, as early as 1850 in diseased animals, for example, the anthrax bacillus in animals dying of splenic fever. So also Schönlein in 1839 had discovered a vegetable parasite, a mycelial form, higher than the bacteria, in the disease of the skin known as favus; Malmsten in 1848 had found a somewhat similar form in barber's itch, and Bassi about 1832 had demonstrated that a disease of the silkworm was due to a minute cryptogamic plant. But the importance of these observations was not widely appreciated and no general relation was established between bacteria and disease in man.

Likewise, theories of infection which explained disease as due to invisible microorganisms had been propounded as early as 1762, as for example that of Plenciz, which, based on Leeuwenhoek's discoveries, ascribed to every disease its particular microorganism, explained the decomposition of animal and vegetable material as due to microorganisms, postulated the growth of bacteria in living tissues and suggested the possibility of the transmission of disease virus by the air. Such views, naturally, were without experimental basis and without even an objective knowledge of the microorganisms supposed to be etiologically concerned. In other words the propounder of this theory, as others after him, believed more than he could prove. By the middle of the century, however, observations on bacteria, largely as the result of the labors of botanists, were accumulating, and views about spontaneous generation, fermentation and infection were being discussed, but the fundamental experiments necessary to settle these problems were yet to be made, and, curiously enough, it was to a chemist, influenced by the methods of physics, who was to establish bacteriology as a biological science and to give to it the important place in medicine which it has occupied for the past thirty years.

Pasteur was this chemist, and his first great discovery was in crystallography, the explanation of the behavior of one of the tartaric acids to polarized light. This acid obtained from the lees of wine was, unlike other acids of the group, inactive to polarized light. This inactivity Pasteur demonstrated to be due to the fact that it was made up of two isomeric constituents. The crystals of one of these constituents bore hemihedral facets on the right side and rotated the plane of polarized light to the right, and those of the other bore similar facets on the left, and therefore, rotated to the left, but, as Pasteur found, when combined, these crystals did not rotate the plane of polarized light at all. This, the first of his discoveries, was in 1848, the year that Virchow was investigating typhus fever in Silesia. If it

is necessary to fix contemporary events more definitely I may introduce the fact that two years later Pasteur quotes Professor Biot as referring to his recent discoveries in crystallography as "a very California."

Now, this work of Pasteur on the tartaric acids not only opened a new field in crystallographic studies, but, of far greater importance, led to the discoverer's studies in fermentation. In the course of his work on the tartaric acids he found that if salts of the inactive acid were acted upon by a mould (*Penicilium glaucum*) the right-handed constituent was destroyed, but the left-handed remained unchanged; and from this he concluded that the change from an optically inactive to an optically active fluid, under such experimental conditions, could be due only to the presence of living matter causing the destruction of one component. This was the beginning of his studies of fermentation, and from this time his labors were those which eventually established the sciences of bacteriology and immunity.

The opportunity to study alcoholic fermentation came at Lille in 1854, at a time when Pasteur was professor of chemistry and dean to the faculty at that place. The manufacturers of the region had met with disappointment in the making of alcohol from beets, and one of them came to the new professor of chemistry for advice. Pasteur undertook daily visits to the factory and from these visits came the idea of studying the fermenting beet juice in the laboratory.

Fermentation, at the time Pasteur entered the field, was a subject involved in great obscurity, with only here and there a ray of light. Cagnaird-Latour, in 1836, had studied that ferment of beer called yeast, and had observed that it was composed of cells "susceptible of reproduction by a sort of budding, and probably acting on sugar through some effect of their vegetation." Schwann and Kützing a few years later reached the same conclusion, but were opposed at once by Liebig, who enunciated a theory of mechanical decomposition and denied in its entirety the theory that fermentation was a biological process. Also Berzelius, second only to Liebig as an authority, believed fermentation was due to contact, and elaborated a theory of catalytic force. With such weighty opposing opinion the observations of Cagnaird-Latour and Kützing were neglected and fermentation was regarded by all as a strange and obscure process and was so characterized by Claude Bernard in 1850.

Uninfluenced by these views, however, Pasteur, having recognized that living matter is essential for alcoholic fermentation, adhered strictly to the experimental method, and taking up the problem of lactic acid fermentation (the souring of milk), discovered that the same budding and multiplying of a cell went on in it as in alcoholic fermentation, but that the cell of lactic acid fermentation was different from that of alcoholic fermentation. He observed also that the form of the

cells changed according to the conditions of fermentation. Incidentally he demonstrated in alcoholic fermentation, the formation of glycerin and succinic acid in addition to the well-known products alcohol and carbonic acid. In short, the outcome was that Pasteur completely demonstrated that the fermentations which lead to the production of alcohol, vinegar, lactic acid and butyric acid are all due to the presence and growth of minute organisms, or, in his own words, "The chemical act of fermentation is essentially a correlative phenomenon of a vital act beginning and ending with it."

The demonstration of the part played by specific microorganisms in the different fermentations was, as may readily be seen, suggestive of the etiology of infectious diseases. It was in the midst of these labors that the Académie des Sciences conferred upon Pasteur the Prize for Experimental Physiology (for 1859), and it was Claude Bernard who drew up the report and dwelt upon the "physiological tendency in Pasteur's researches." Ten years before, Bernard had characterized the process of fermentation as "obscure."

The results of the investigation of fermentation led naturally to a debate among the academicians concerning spontaneous generation, and in this dispute Pasteur took a most important part. The older examples of spontaneous generation, as, for example, the development of mice from a mixture of soiled linen and cheese and of maggots from decomposing meat, had long been discarded, but the demonstration that fermentation and putrefaction were due to microscopic living organisms raised the question: Whence comes this microscopic life? Do or do not these bodies arise spontaneously in putrescible and fermentable fluids? The results of several investigations were already at hand. Thus Spallanzani (1769) had shown that if a putrescible fluid was hermetically sealed in flasks and the flasks heated in boiling water, decomposition did not occur; Schulze (1836) had obtained the same result by filtering through strong solutions of acids and alkalies the air which entered such flasks, as had also Schwann (1837), by first passing the air through heated tubes; and likewise Schroeder and Dusch (1854) by filtering the air through cotton plugs. All these procedures robbed the air of the suspended microorganisms and, as the fluids had previously been sterilized by heat, decomposition did not occur. But at the time these procedures, though now recognized as the basic principles of bacteriological technique, as applied to sterilization and asepsis, did not gain general credence. "Philosophic argumentation always returned to the fore." The theory of spontaneous generation would not down, and from 1858 to 1862 it was the most important matter of debate in the discussions of the Académie des Sciences.

Pouchet and Pasteur were the disputants, the former defending the thesis that "animals and plants could be generated in a medium abso-

lutely free from atmospheric air, and into which, therefore, no germ or organic bodies could have been brought by the air"; the latter insisting that only through the entrance of such living organisms could the changes in question take place. The discussion lasted several years, and to-day presents many interesting details, but it may suffice to state that it was ended by Pasteur's demonstration that if the neck of a flask was drawn out into a fine tube and bent into a double curve and the flask then heated by boiling, no decomposition occurred. The flask was open to the atmospheric air, but the microorganisms of the air were arrested by the drop of water of condensation, in the lower point of the curved neck. This demonstration, with the later work of Cohn on spores and of Tyndall on floating matter in the air, disposed of the doctrine of spontaneous generation and led to the universal acceptance of Harvey's law *Omne vivum ex ovo,* or as it was modified, *Omne vivum ex vivo.*

It is not surprising that Pasteur at this time foresaw the possibilities in the study of the etiology of the infectious diseases. The process of fermentation, due to living microorganisms, and beginning with a period of apparent inactivity, passing on to a stage of very evident activity and finally sinking gradually into quiescence, was analogous to the period of incubation, the stage of active manifestations and the gradual defervescence of an infectious disease. Also the specificity of the ferments was evidently suggestive of the specific etiology of disease, and altogether we see from several of Pasteur's statements at this time that the relation of microscopic organisms to disease occupied his mind. Thus in a letter to his father, in 1860, he expressed the hope that he may, "bring a little stone to the frail and ill-assured edifice of our knowledge of those deep mysteries of Life and Death where all our intellects have so lamentably failed" and in 1863, after an audience with Napoleon III., he writes, "I assured the Emperor that all my ambition was to arrive at the knowledge of the causes of putrid and contagious diseases."

And now with that peculiar trick of coincidence that is so surprising in the course of culture and inquiry, we find that about this time bacteriology began to make advances along three general lines of study: (1) The etiology of the acute infectious diseases; (2) the prevention of infection, and (3) the achievement of cure or immunity by vaccination. In the first and third of these, Pasteur played a prominent part and it was his work on fermentation which suggested the second to Lister. Pasteur's entrance into the field of etiology and the results he there accomplished form one of the most interesting phases of the history of science and its outcome, a matter of the greatest economic importance to France. The opportunity to study an infectious disease was offered by an epidemic of a mysterious disease which was ruining

the silkworm industry. Whence the disease came or how it was contracted no one knew. Its onset was recognized only by the presence of the little brown or blackish spot from which it got its name (pébrine). Pasteur, who undertook the investigation at the request of his old master Dumas, now a senator, knew nothing of the industry and, as he wrote Dumas, "had never touched a silkworm." But under pressure of Dumas's solicitation he finally yielded, and found himself, a chemist, hitherto interested chiefly in the study of crystallography and fermentation, thrown at once into a new and strange field. That his results were due largely to the training and the point of view obtained through the study of fermentation and the use of the microscope, there can be little doubt, and one is inclined to apply to Pasteur at this stage of his work his own statement of ten years before; "in the fields of observation, chance favors only the mind which is prepared."

Once in the silkworm country he applied himself energetically to the study of the "fatal spots." The story of the complete investigation is a long one, but the main points are that within a month he found that although worms, moths and eggs were infected, the critical stage was the infection of the moths, and that, in these, the infection could be readily demonstrated with the aid of the microscope, and, that having demonstrated this, the remedy lay in using the eggs of non-infected moths only. Thus a new breed of worms free from infection could be obtained and the extension of the disease arrested. In the course of this work he reproduced the disease experimentally by feeding healthy moths with infected mulberry leaves, a novel procedure then, but one, which, with its modifications, was soon to become a commonplace principle of bacteriological investigation. The investigation of the silkworm problem lasted for five years, or until Pasteur cleared up not only the difficulties connected with pébrine, a disease due to infection with a psorosperm, but unmasked also a second disease of the silkworm (flâcherie), a bacterial infection of intestinal origin.

In the meantime Pasteur continued his studies of the diseases of wines (sour, bitter and muddy wines) and invented the process known then and now as "pasteurization." This was the simple process of heating the wine in order to free it of all germs of wine disease and make it suitable for storage and exportation. In this connection he expresses the greatest satisfaction that he was thus able to contribute to the national riches through the practical application of his observations. In 1867 he said:

> Nothing is more agreeable to a man who has made science his career than to increase the number of discoveries, but his cup of joy is full when the result of his observations is put to immediate practical test.

The term, pasteurization, is now most frequently heard in connection with milk, but when it is recalled that all commercial and

domestic methods of canning and preserving solid and fluid foods are based on the laboratory experiments of Pasteur one obtains an adequate idea of the importance of his observations and likewise appreciates his satisfaction at the practical application of his methods.

As the silkworm problem began to clear up, Pasteur's thoughts turned more and more to the etiology of the acute infectious diseases of man and animals and their experimental study. This is shown in his appeal to the government (1867) for a laboratory. In this appeal he refers to the advisability of investigating splenic fever and asks, "How can researches be attempted on gangrene, virus or inoculations, without a building suitable for the housing of animals?" and in 1871, in his book on beer, with the diseases of which he had busied himself, we again find a reference to the possibility of the disease of man and animals being due to microorganisms. Here again it is evident that he was influenced by the idea of microorganisms invisibly introduced into fermentable fluids, for in this connection he says, "it is impossible not to be pursued by the thought that similar acts may, *must,* take place in animals and in man"; but without experimental proof he refused to go further.

Pasteur's attack on animal diseases was, however, delayed, first by a cerebral hemorrhage in 1868 which left him partly paralyzed, and then by the Franco-Prussian war which interrupted all scientific efforts in Paris.

Here it is well to pause a moment to consider the attitude of the medical profession towards the theory which was beginning to take shape as the "germ theory." The following decade was to see the bacterial etiology of several important diseases established, Lister's practise of antisepsis in surgery quite generally accepted, and the principle of specific vaccine treatment demonstrated. To-day no phase of medicine is so well understood by the world at large as that of bacteriological principles and aims. Germs and sera, prophylaxis and quarantine, antisepsis and pasteurization, are matters of common knowledge and of ordinary conversation, but it is difficult for one unfamiliar with pre-bacteriology days to appreciate the views which had to be combated only forty years ago. A brief glance at the conditions in 1873 may therefore give you a better appreciation of the events of the succeeding decade. If it is necessary to fix the period, let me remind you that 1873 was the year the University of California removed to its present site.

The Franco-Prussian war had come to a close. Surgeons remembered that though soldiers were killed in battle by tens and hundreds, they died of surgical diseases by thousands.

In the hospitals surgical sepsis ran rampant. Secondary hemorrhage, erysipelas, pyemia and ''hospital gangrene'' were endemic. Sometimes wards, wings

or whole institutions were closed in vain attempts to stamp out these disorders. (Mumford.)

The causes were unknown and the remedies, therefore, not at hand. Of this period we read with amazement that

Sometimes a surgeon would wear the same old operating coat for years, and would pick waxed ligatures from the button hole of his assistant who carried them there for the convenience of his chief. (Mumford.)

To-day, we refer to it as "a barbarous era," but before Lister the most conscientious surgeon had no reason to do otherwise than has been described.

And, likewise, internal medicine, although it had benefited by improvements in the methods of physical diagnosis and by the application of the principles of pathological anatomy, had made no progress in the prevention and treatment of the infectious diseases. In the presence of these scourges of humanity the physician was not only helpless, but indifferent to the occasional illuminating discoveries of the exact thinker or investigator. Many examples of this indifference are at hand. In the writings of Henle (1840–1853) was announced a rational theory of infection, but it was ignored. Oliver Wendell Holmes (1843 and 1855) had brought forth a great body of facts indicating that puerperal fever was "so far contagious as to be carried from patient to patient by physicians and nurses," and Semmelweis in 1847, working in the old Vienna hospital, had asserted that the mortality from this disease could be reduced from 12 and 16 per cent. to 3 per cent. (later he reduced it to less than 1 per cent.) by the simple procedure of cleansing, in a solution of chlorinated lime water, the hands of those concerned in obstetrical work. The views of Holmes and Semmelweis, however, were ridiculed and the simple antiseptic procedure of the latter was not continued, and when Villemin, thirteen years before Koch discovered the tubercle bacilli, demonstrated by exact experimentation the transmission of tuberculosis to animals, and announced that the disease was a specific transmissible disease, "he was treated almost as a perturber of medical order." I know of nothing which so clearly shows the state of mind of the profession of that day as the remark of Pidoux in criticizing Villemin's work. Referring to the doctrines of specificity he says,

These doctrines condemn us to the research of specific remedies or vaccines and all progress is arrested. . . . Specificity immobilizes medicine.

This representative of traditional medicine could see no relation between Villemin's experiments in which guinea pigs were brought into contact with the dried sputum of tuberculous patients and Pasteur's theory of germs floating in the air being responsible for the various fermentations.

So, likewise, it was with Davaine's demonstration (1863) of bacteria

in the blood of animals dying with anthrax. His view that these micro-organisms, multiplying rapidly in the blood, were in their action analogous to Pasteur's ferments and responsible for the death of the animal, was received only with arguments and did not immediately stimulate investigation, despite his proof of experimental production of the disease by inoculation. To us, who know to-day the fruits of the study of specific etiology and specific therapy, the opposition to the views of Villemin and Davaine and others is almost incomprehensible, but it must be remembered that these views were the fruits of a new type of investigation in practical medicine, that of laboratory research which came close to the sacred precincts of the clinic. "This was the time," in France at least, "when the 'princes of science' or those who were considered as such, were chiefly physicians. The almost daily habit of advising and counselling" gave them a haughty superiority, and views not based on clinical researches were set aside as unsound. Physiology and chemistry applied to the normal individual were well enough, and pathological anatomy with the post-mortem room as an adjunct to the clinic was very proper, but for the laboratory investigator to invade the clinic and present his views concerning the cause of disease or to explain its phenomena was another matter. A well-known surgeon of that time stated:

> Laboratory results should be brought out in a circumspect, modest and reserved manner, as long as they have not been sanctioned by long clinical researches.

But at the very time (1873) of this statement, the forces which were to make the era of laboratory research the greatest of medical eras were already at work; Hoppe-Seyler was establishing (1872) the first laboratory of physiological chemistry, v. Recklinghausen was studying the wanderings of the white blood cell, Weigert was staining bacteria with carmine, Ehrlich was applying dyes to the study of the cells of the blood (both later developed the use of the aniline dyes in histological and bacteriological technic), Abbe was developing his condensing system of illumination for the microscope, Cohn was classifying bacteria according to their morphology, Klebs was separating bacteria from their culture fluid by filtration through animal cells, Pettenkoffer was studying the relation of water to epidemics of typhoid fever and cholera, Obermeier had found a parasite in the blood of relapsing fever, and Koch, a country physician, was carrying on those early researches which were soon to make him the leader in the science of bacteriology. At the same time (since 1866), pathologists (Rindfleish, v. Recklinghausen, Waldeyer, Birch-Hirschfeld and Klebs) had been examining individuals dying of septicemia, pyemia, erysipelas, abscess, inflamed wounds, etc., and had found bacteria in all these lesions, Birch-Hirschfeld, moreover, had called attention to the resemblance, in

pyemia, between the bacteria of the local lesion and those in the internal organs, and had observed bacteria within the leucocyte. To us, who view these activities in retrospect, they are phases of a general advance, the culmination of which is common knowledge, but in the early seventies they were merely the non-related efforts of individual workers. Some practical demonstration was necessary to give to the newer type of laboratory work an importance which would impress the profession. Such a demonstration came through Lister's antiseptic treatment of wounds and was followed shortly by the observations of Koch on anthrax, and of Pasteur on vaccination against bacterial disease.

Lister's first publication concerning his treatment of wounds was in 1867, but it was not until the late seventies that his views were quite generally accepted. In the meantime his methods and their results served to concentrate attention on bacteria and their relation to the diseases of man. He regarded wound infection as putrefaction due to the invasion of the wound by minute microorganisms of the air; a conception which, as he acknowledges in his first publication, was suggested by Pasteur's work on fermentation. In a letter to Pasteur in 1874 he offers "most cordial thanks for having demonstrated to me the germ theory of putrefaction, and thus furnished me with the principle upon which alone the antiseptic treatment can be carried out."

His method was to combat this air-borne infection with an antiseptic—carbolic acid. He cleaned a wound by wiping it out with carbolic acid and then sealed it with lint soaked in this acid. All instruments, sponges and dressings coming in contact with the wound or the hands of the operator or assistants, as well as the site of operation, were cleansed in the same way. Also, by means of a vaporizer, carbolic acid was sprayed into the atmosphere about the site of operation. As years passed the details of this method changed. We now speak of the suppuration of wounds, not of putrefaction; the carbolic spray has been abandoned and our ideas about sepsis have been modified in several ways, but the principle remains as Lister conceived it. The beneficial results of this new treatment in Lister's hands were immediate, but its general application came slowly. We find Pasteur in 1874 referring to Lister's "marvellous surgical methods" and recommending to the surgeons of Paris the use of instruments and dressings sterilized by heat. The complete acceptance of Lister's principle would appear to correspond to the year 1883, when he was made a baronet.

The benefits of antisepsis are now so familiar to us, and its use so much a matter of routine, that we cease to wonder at the revolution it brought about in surgery. Some diseases, as hospital gangrene, it has abolished entirely; others as the septic surgical diseases of former days have been reduced almost to nil; it has robbed the period of child-bearing of one of its chief perils, and has opened to surgery regions and

cavities of the body previously closed on account of the great mortality due to sepsis. Antisepsis shares with anesthesia, as its discoverer, Lister, shares with Morton, Warren and Simpson, the honor of the great advances surgery has made in the treatment of disease and injuries of the abdomen, thorax and the cranial cavity. Who can compute the relief from suffering and the saving of life which may be traced through Lister to Pasteur's laboratory experiments on fermentation?

The recognition of the principle of asepsis by the surgeons was, then, as we have seen, slow and grudging enough; among the profession at large the theory of infection as applied to acute diseases gained more slowly still. It was not until 1880 that advance in the knowledge of the bacterial etiology of infectious diseases assumed such definite shape as to attract general attention. As we look back upon this early work we see clearly that one reason for this slow advance was the absence of proper methods of isolating bacteria in what we now call pure cultures. Pasteur and his co-laborers made (1) direct search for bacteria in the secretions, blood or tissue juices, or (2) inoculated fluid media or animals with such material. By the first of these methods it was possible to recognize bacteria if they were especially abundant, as in anthrax, and it was by this method that Neisser discovered the gonococcus (1879) and Hansen the leprosy bacillus (1879), bacteria which are particularly abundant in the local lesions of the respective diseases. The second method, the use of fluid media, was satisfactory if the material for study contained only one type of organism; if more than one it was obviously difficult to study the life history of a bacterium or to obtain exact results by the inoculation on account of the simultaneous growth of associated or contaminating organisms. This difficulty was overcome by Koch, in 1881, through the introduction of solid culture media. Koch had already, while a country practitioner, definitely and clearly established the relation of the anthrax bacillus to the splenic fever of cattle and had demonstrated in this organism the formation of spores and their importance; also he had published most important observations on the bacteriology of wound infection. The use of solid media, which it is said was suggested to Koch by the growth of mould on potato, led at once to rapid advance, for as each bacterium placed on a solid medium causes, as it multiplies, the growth of a visible colony, it was possible to distinguish colonies having different characteristics and by transplantation to secure pure cultures. The demonstration of Koch's solid media and plate method at the Congress of Hygiene in London in 1881 caused Pasteur to exclaim "C'est un grand-progrés." This advance and the use of microscopes equipped with the oil immersion lens and the Abbe condenser, and the increased knowledge concerning the use of the aniline dyes for staining purposes gave

to bacteriology the technique necessary for its rapid development. Koch was called to the Imperial Board of Health in Berlin in 1880, and started the first laboratory founded for the study of bacteriology and public health problems. In this laboratory, methods of studying and photographing bacteria were developed, methods of disinfection based on the knowledge of spore resistance were elaborated, and the study of the bacteriology of individual diseases inaugurated. As a result of the latter activity, he announced, in 1882, the discovery of the bacillus of tuberculosis, and it is not too much to say that his announcement astounded and profoundly stirred the entire civilized world. In the same year Löffler and Shütz announced the discovery of the bacillus of glanders, and Pasteur published an account of the bacteriology of swine erysipelas; this was the beginning of an active period with discovery crowding on discovery. In 1883 came Koch's announcement of the comma bacillus as the cause of cholera; in 1884 Löffler's description of the bacillus of diphtheria and Nicolaier's discovery of the bacillus of tetanus. So the march of discovery continued until the roll of diseases of known etiology in a short time included typhoid fever, pneumonia, meningitis, influenza, bubonic plague and the various surgical suppurations.

The rapid discoveries of disease-producing microorganisms established definitely Pasteur's doctrine of specificity as applied to etiology and led at once to an interest in public health measures which increased as the years passed, until now it has become one of the most vital interests of our social system. Even in the early eighties, with a knowledge of the etiology and mode of transmission of a few diseases and of Lister's results in antiseptic surgery, it was possible to postulate general prophylactic measures safeguarding the individual and the community, and as knowledge of etiology and transmission increased, so did prophylaxis. Hygeia was again enthroned and it was recognized that "an ounce of prevention is worth a pound of cure."

But prophylaxis was not entirely satisfying. If a specific etiology, why not a specific therapy for bacterial diseases? Men remembered inoculation for smallpox introduced into England by Lady Mary Wortley Montagu early in the eighteenth century. This procedure, the inoculation of healthy individuals with material from the pustules of those ill with a mild form of smallpox had materially reduced the fatality of the disease. The procedure, it is true, had been made illegal in England in 1840, because of the greater success and less danger of Jenner's wonderful discovery (1798) of vaccination with the fluid of the pustule of cowpox. Inoculation, however, despite the fact that it sometimes caused severe and fatal cases of smallpox and perpetuated foci for the dissemination of the disease, had demonstrated that the mild inoculation disease usually protected against the more severe forms. That

Jenner's vaccine was a transmitted cowpox did not militate against the general theory of protecting the individual against a severe form of a disease by the production of a mild form, for cowpox was generally considered to be smallpox modified by passage through another host, the bovine animal. If such results could be obtained against a disease, small-pox, the causal agent of which was unknown, how much easier to vaccinate against a disease of known etiology!

This was therefore the first line of attack in the battle for a specific therapy of the infectious diseases. Already Pasteur was at work. An epidemic of chicken-cholera, in 1880, offered the opportunity for extended experiments. In the course of this work, a chance observation gave him the clue to vaccination with bacteria of attenuated virulence. It had been his routine practise in the experimental production of chicken cholera to use fresh 24-hour cultures; these always produced the disease readily. But in the course of the work it happened that an old culture which had been set aside for a few weeks and forgotten, was used, with the unexpected result that the inoculated hens, although ill for a while, promptly recovered, and what was more surprising, remained refractory to subsequent inoculation of fresh cultures, though the same cultures were virulent for untreated hens. This phenomenon. the attenuation of virulence due to artificial cultivation, Pasteur used as the basis of a treatment by vaccination, which had the immediate effect (1880) of reducing the mortality of chicken cholera to one per cent. and the more remote but far more important effect of stimulating the study of specific therapy. Incidentally it was the link between Lady Mary Wortley Montagu's preventive inoculation and Jenner's vaccination, on the one hand, and modern theories of the production of immunity on the other.

The next step was with anthrax, a disease of cattle. The attenuation of chicken cholera virus had been due to artificial cultivation, but about this time Toussaint, of the veterinary school of Toulouse, made some observation on the attenuation of anthrax bacilli under the influence of increased temperature (heating to 55° C. for ten minutes). His observations, however, were without constant results. Pasteur, who was familiar with Toussaint's work, took up the matter and after a thorough investigation found that anthrax bacilli cultivated at a temperature of 42° to 43° C., became attenuated, and this attenuation persisted on artificial cultivation (1881). The inoculation of such organisms did not cause anthrax, and when later virulent bacilli of anthrax were inoculated, the animals were found to be immune. This was the scientific basis of the celebrated public test at Melun. Sixty sheep and ten cows were placed at the disposal of Pasteur; twenty-five of the sheep and six of the cows were to be vaccinated with attenuated anthrax bacilli, and after an interval of twelve to fifteen days this was to be

repeated. Later this lot, and also twenty-five untreated sheep and four untreated cows, were to be inoculated with a virulent culture of anthrax bacilli. Ten sheep were to have no treatment at all. "The twenty-five unvaccinated sheep will all perish," wrote Pasteur, "the twenty-five vaccinated ones will survive." This magnificent faith based on exact experimentation was justified. All happened as Pasteur predicted. For medicine a new era was at hand; Huxley, in 1880, estimated that the money value of the results of Pasteur's vaccination treatment was sufficient to cover the war indemnity paid by France to Germany in 1879. As the years go by and the influence of Pasteur widens the horizon of preventive medicine and the treatment of disease by immunizing methods, civilization's indebtedness to Pasteur is almost beyond the grasp of the imagination.

His discoveries in vaccination against swine erysipelas and hydrophobia are as fascinating, in their "mingling of experimental skill and scientific imagination" (Herter), as all that he did before. But while Pasteur is an engaging figure, worthy of much more than this simple lecture that we are devoting to him, yet he is not the whole story, and at this point we must turn away from him and proceed to another line of advance: one, however, which was in part the result of his genius and his indefatigable labor. This, the discovery of antitoxic sera, will be discussed in the next lecture, in connection with other modern problems and methods in medical research. But here let me remind you that it was Pasteur, afflicted at the age of 46 with a hemiplegic paralysis—which, by the way, left its traces during the remaining twenty-five years of his life—who said,

> Work can be made into a pleasure, and *alone* is profitable to a man, to his country, to the world.

It would be difficult to find in any field of human endeavor an individual whose life and labors exemplified this precept better than do the life and labors of Louis Pasteur.

TRINIDAD AND BERMUDEZ ASPHALTS AND THEIR USE IN HIGHWAY CONSTRUCTION

By CLIFFORD RICHARDSON, M. Am. Soc. C. E.
NEW YORK CITY

BITUMEN in its various forms is widely distributed in nature, as natural gas, petroleum, maltha, asphalt and other solid forms. Of the deposits of asphalt which are of great industrial importance there are two which have attracted world wide attention, the so-called Trinidad Pitch Lake and the Bermudez Pitch Lake, the name lake being applied to them very naturally, as they consist of a great expanse of more or less mobile character, covering many acres, and resembling in many ways a similar expanse of water. It is proposed, in the following pages, to give an account of these remarkable deposits, the manner of exploiting them and their industrial applications in highway construction.

The Trinidad Pitch Lake

The Island of Trinidad lies off the north coast of South America, between 10° and 11° of latitude and 61° and 62° longitude. It is bounded on the north by the Caribbean Sea, on the east by the Atlantic, on the south by a narrow channel, into which flow the waters of the northern and most westerly mouths of the Orinoco, and on the west by the Gulf of Paria, the two latter bodies of water separating it from the mainland of Venezuela.

It is of an irregular rectangular shape, with promontories extending from its southwestern and northwestern corners which are several miles in length, between which and the mainland are the narrow straits known as the Dragon's and Serpent's Mouths. These promontories from a large portion of the northern and southern boundaries of the shallow rectangular Gulf of Paria, whose outlets to the ocean are through the Dragon's and Serpent's Mouths. The island has an average length of 48 miles and breadth of 36, containing about 1,750 square miles, and being about one fifth the area of the state of Vermont. It is, as a whole, a flat country, with a high and striking mountain chain descending abruptly into the sea along its northern shore, and with low central and southern ranges of less importance. Its coasts are naturally abrupt on the north, consist of low bluffs on the south and are flat on the east and west. The only harbors are on the western coast.

Photo, C. R. Toothaker, Phila. Commercial Museum.

TRINIDAD PITCH LAKE.

The shape and structure of the long promontories which have been mentioned reveal the fact that Trinidad is, structurally, intimately connected with the mainland. This is proved by the geology and fauna of the island, the latter corresponding closely to that of the mainland and the geological structure being a continuation of that of the continent. Its climate is entirely tropical and somewhat different from that of the remaining Antilles in this respect.

Trinidad was discovered by Columbus on his third voyage in 1498 and taken possession of in the name of Spain, which colonized it about ninety years after. In 1797 it was taken by Great Britain, and has remained since then one of her most important West Indian colonies, and the second in size.

The Island of Trinidad, while not directly connected with the chain of islands of volcanic origin known as the Windward or Caribbean Islands, is directly on the great line of volcanic disturbances running from these to the continent of South America and its volcanic regions. Many of the Windward Islands are still possessed of active vents, so that Trinidad may be looked upon, with its thermal springs and pitch deposits, as being situated at the lowest point between the mountainous volcanic chains of the West Indies and those of South America. More than two thirds of the surface is of Tertiary or recent origin, including the entire southern portion, where the pitch deposits are located. The formations consist of clay, loose sand, shales, limestones, calcareous sandstones, indurated clays, porcelainites of brilliant colors, with pitch deposits here and there. The beds have been considerably disturbed and have at times a large dip. In a series of sands, clays and shales lies the pitch lake.

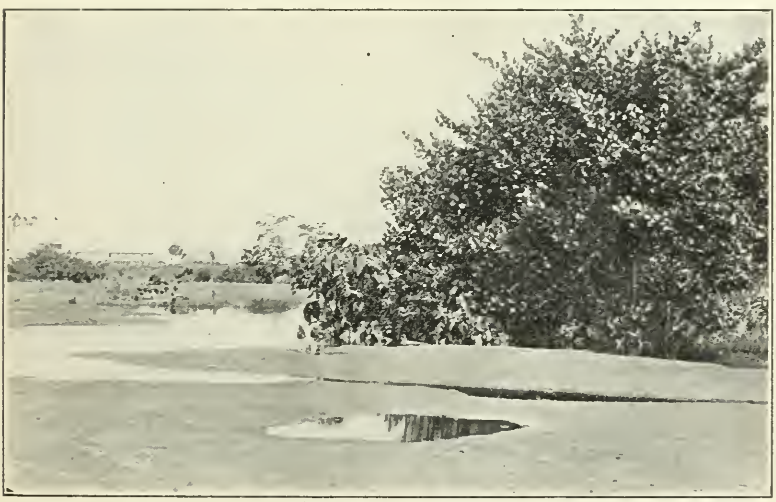
While there are deposits of pitch scattered all over the island, the only ones of commercial importance are those situated on La Brea Point,

in the wards of La Brea and Guapo, in the County of St. Patrick, on the western shore of the island. They are about 28 miles in an air line from Port of Spain, the seat of government, the chief harbor and only port of entrance, and lie on the north shore of the southwestern peninsula, the point on which they are situated being apparently preserved from destruction by the sea, which is elsewhere rapidly wearing away the coast, by the bituminous deposits which exist along the shore and even some distance from it, and which from their toughness resist the action of the waves better than the soft rocks of this region. The pitch deposits are found scattered over the point, but can be divided conveniently into two classes, according to their source.

The main deposit is a body of pitch known as the pitch lake, situated at the highest part of the point. Between this and the sea, and more especially toward La Brea, are other deposits, covered more or less and mixed with soil. The pitch from these sources is classified as "lake pitch" and "land pitch."

By far the largest amount of pitch is found apparently in the pitch lake, a nearly circular area of 114.67 acres, 138-feet above sea level. From the lake the ground falls away on all sides, except, perhaps, a slight ridge to the east and southeast, in fact, it seems plain that this deposit lies in the crater of a large mud volcano which has been filled up with pitch.

In past times the pitch very probably continued to collect until it overflowed the rim of the crater, particularly toward the north, and thus perhaps became the source of some or all of the land pitch deposits now found between the lake and the sea.



Photo, C. R. Toothaker, Phila. Commercial Museum.

Border of Lake.

Photo, C. R. Toothaker, Phila. Commercial Museum.

SOFT ASPHALT RISING THROUGH WATER.

The surface of the deposit or lake is not a uniform expanse of pitch. It is grassy along the edges and becomes free from vegetation at some distance from the center. Shrubs and small trees occur in a few cases known as islands. These patches move from place to place with the movement of the pitch at the surface. The main mass of asphalt is a broad expanse of pitch made up of separate areas of irregular outline, but at times quite circular, which are separated by channels, filled with rain water, which prevents their coalescence. The boundaries are depressed and the center of the areas is always somewhat elevated above the edges, that is to say, they are mushroom-like. The origin of the separate areas evidently lies in the constant movement of the crude material, due

Photo, C. R. Toothaker, Phila. Commercial Museum.

EVOLUTION OF GAS IN WATER.

to the evolution of gas at the center, from which point the pitch rolls over toward the edges. This is shown by the fact that pieces of wood which emerge erect at the center are gradually carried to the circumference, their deflection from the perpendicular increasing as the distance from the center increases. At the channel they topple over and are again engulfed in the pitch. This illustrates very well the activity of the entire surface of the deposit, although it is much more active near the center of the lake.

As to the depth of the lake, borings made in 1894 at the center, were carried to a depth of 135 feet, by means of a wash drill, the entire distance being through asphalt of the same character as that at the surface. This result shows the great depth of the crater, and the uni-

Photo, C. R. Toothaker, Phila. Commercial Museum.

FLAKING OUT THE PITCH.

formity of the material which it contains. At the pitch lake, therefore, at a point 138 feet above the sea, there is a bowl-like depression, more than two thousand feet across, and over 135 feet deep, reaching to the sea level, and filled with a uniform mass of asphalt, a mass which must amount to many million of tons, making it the largest deposit of solid native bitumen in the world.

The material forming this deposit is an emulsion of water, gas, bitumen and mineral matter, the latter consisting largely of fine sand and a lesser amount of clay. It is in constant motion, owing to the evolution of gas, and for this reason whenever a hole is dug in the surface, whether deep or shallow, it rapidly fills up, and the surface resumes its original level after a short time. While sufficiently soft to accommodate itself to any change of level and to slow movement, it can be readily

flaked out with picks, in large conchoidal masses weighing from 50 to 75 pounds. It is honeycombed with gas cavities, and resembles in appearance the structure of a Swiss cheese. The gas evolved by the pitch consists of hydrogen sulphide and carbon dioxide, but in such proportions that it burns readily when a match is applied, although the flame is not maintained for any length of time.

In the center of the so-called lake is a point where there is a continued influx of soft material, accompanied by a stronger evolution of gas, which gradually hardens and becomes like the remainder of the deposit. The point of evolution of the soft material moves about from

Photo, W. H. Rau, Philadelphia.

Winning the Crude Pitch, Refinery in Distance.

place to place along lines of least resistance. As that evolved at one point hardens the fresh material breaks out elsewhere. It is peculiar in that it is associated with so much free water which rises with it, that it can be handled freely and made into a ball without adhering to the hands. It is in an active state of change, since if it is sealed in a tin can the gas evolved will, in a few weeks, burst the containing vessel.

The temperature of the pitch at the surface is no greater than that of the surrounding air except when it is exposed to the noon-day sun, when it may rise to 130° F. or over. That of the soft pitch is no higher than any other part of the deposit.

Photo, C. R. Toothaker, Phila. Commercial Museum.

LOADING THE CRUDE PITCH ON CARS.

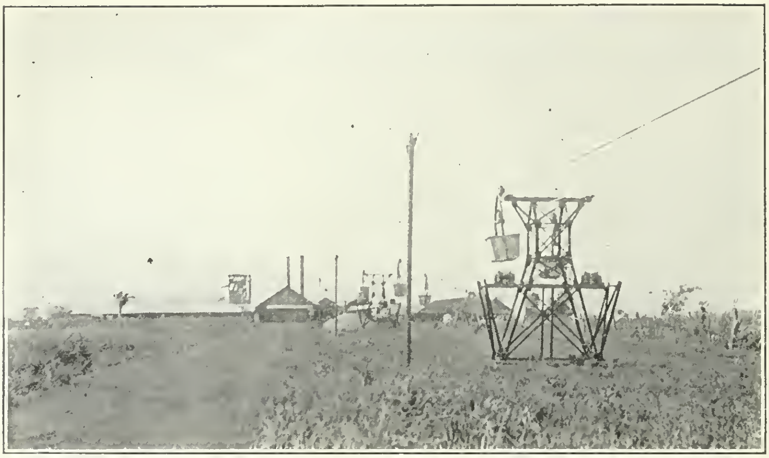
	Crude Per Cent.	Dry Per Cent.
Water and gas, volatilized at 100° C.	29.0	
Bitumen soluble in cold carbon disulphide	39.0	56.5
Bitumen retained by mineral matter	.3	.3
Mineral matter, on ignition with tricalcium-phosphate	27.2	38.5
Water of hydration in clay and silicate	3.3	4.2
	98.8	99.5

COMPOSITION OF THE ASPHALT

An examination of the asphalt shows that it is one of extreme uniformity in composition. It consists of, according to the most refined methods of analysis, from whatever part of the deposit it is taken:

Photo, C. R. Toothaker, Phila. Commercial Museum.

LOADING THE CRUDE PITCH ON CARS.



Photo, C. R. Toothaker, Phila. Commercial Museum.

TRANSPORTATION OF PITCH BY AERIAL CABLE FROM REFINERY TO PIER.

The average composition of samples taken on circles 200, 400, 600, 800, 1,000 and 1,100 feet from the center of the deposits, and for the average material from the entire depth of the boring, as determined by routine methods, was found, after drying the material to free it from the water which is present, to be as follows:

AVERAGE COMPOSITION OF TRINIDAD LAKE PITCH IN CIRCLES

	Bit. by CS_2, Per Cent.	Mineral Matter, Per Cent.	Organic not Soluble, Per Cent.	Soluble in Naphtha, Per Cent.	Total Bitumen thus Soluble, Per Cent.
Circle 2, 200 ft. from center......	55.02	35.41	9.57	31.83	57.85
Circle 4, 400 ft. from center......	54.99	35.40	9.61	31.63	57.55
Circle 6, 600 ft. from center......	54.84	35.59	9.67	31.85	58.26
Circle 8, 800 ft. from center......	54.66	35.56	9.78	31.67	57.97
Circle 10, 1,000 ft. from center..	54.78	35.44	9.78	31.58	57.64
Circle 12, 1,100 ft. from center..	54.62	35.45	9.93	31.77	57.51
General average	54.92	35.46	9.72	31.72	57.79
Circle 14, 14,000 ft. from center.	53.86	36.38	9.76	30.52	56.66

The great uniformity of the deposit is revealed by these figures.

The water is probably of thermal origin, as it contains borates and iodides. Chlorides and sulphates of sodium are the predominating salts, sulphate of ammonia in marked amount, while chloride of potassium, lime and magnesium and ferrous iron are present. It is impossible to separate the water from the bitumen without change, but in the old methods of refining pools of it would collect on the surface of the asphalt, and this water, although somewhat concentrated and oxidized, had the following composition:

Analysis of Asphalt Water

Specific gravity 1,017 · 15° C./15° C. Reaction strongly acid
In 1 kilogram

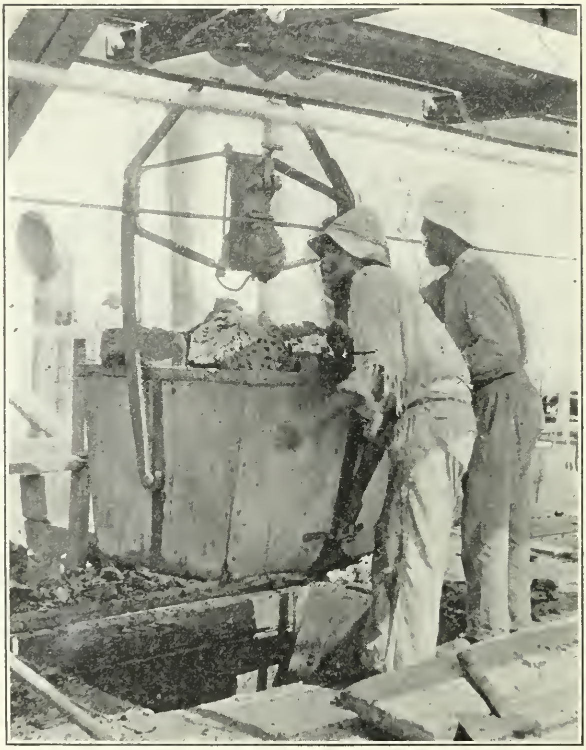
Cl	6.7757	NH_4	.4071
SO_3	5.5409	K	.3391
SO_2	.0467	Li	.0271
S_2O_7	Traces	Ca	.5280
H_2S	Traces	Mg	.2666
S	Traces	Fe	.0720
SiO_2	.0688	Al	Trace
B_2O_3	.0117	Mn	None
I	.0008	Cs and Rb	None
Br	Trace	Organic	.4901
P_2O_5	None	Oxygen	——
Na	6.5149		21.0896

The percentage of soluble mineral matter or salts as compared to that of the bitumen is extremely small and unimportant, and plays no part in the behavior of the material industrially, since the addition of the same salts to other asphalts has been found to produce no perceptible effect upon them.

For many years Trinidad asphalt was supposed to contain a considerable amount of organic matter not of a bituminous nature, but an investigation conducted by me in 1908 showed that this really consists

Photo, W. H. Rau, Philadelphia.

Road from Lake to Pier, Pier in Distance.



Photo, C. R. Toothaker, Phila. Commercial Museum.
DUMPING CRUDE ASPHALT INTO HOLD OF VESSEL.

of the water of hydration of the clay forming part of the mineral matter, which was lost on ignition after the removal of the bitumen by solvents, and that, as a matter of fact, there is practically nothing of the nature of the organic matter not bitumen which has heretofore been attributed to Trinidad asphalt.

In direct contrast to this acid water is that which rises with the soft pitch in the center of the lake, which is alkaline in reaction, and has the following composition:

	Grams per Kilo
Specific gravity	1.0599
Solids at 110° C.	82.100
Sodium, Na	27.193
Potassium, K	0.528
Chlorine, Cl	38.210
Sulphuric acid, SO_3	3.207
Calcium oxide, CaO	Trace
Magnesium oxide, MgO	0.506
Carbonic acid, CO_2	3.700
Silica, SiO_2	0.222
Organic matter	?
	73.566

The emulsified water can be removed from the crude Trinidad asphalt by grinding it to a fine powder and exposure to the air, or by heating the material to a temperature above the boiling point of water, and until the bitumen melts. Upon the latter fact is based the process of refining which is used industrially, and which will be described later.

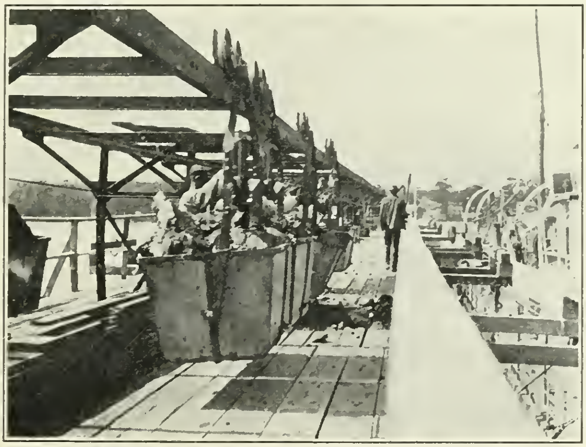
The bitumen of Trinidad asphalt can be separated from the mineral matter by solvents, and thus prepared is a brilliant, glossy, pitchlike substance, which has a semi-conchoidal fracture when struck a sharp blow, but which yields to gentle pressure and slowly flows at summer temperatures. It softens at 76° C., flows quickly, at 83° C., but is not liquid until a temperature is reached which is above 100° C. It has a specific gravity, when entirely free from mineral matter, of 1.032 at 25° C.

Its ultimate composition is

Carbon	82.33
Hydrogen	10.69
Sulphur	6.16
Nitrogen	0.81
	99.99

It is noticeable that this bitumen is characterized by the large percentage of sulphur which it contains, by the presence of nitrogen, and by the absence of oxygen.

It is to the sulphur which is present, as will be shown later on, that the valuable properties of the Trinidad bitumen are to be attributed.



Photo, C. R. Toothaker, Phila. Commercial Museum.

Pier with Crude Asphalt in Buckets.

Photo, W. H. Rau, Philadelphia.

Pier at Brighton, Trinidad, from Shore.

It consists, like all the other more or less solid native bitumens, of components of two different classes, which can be separated by solvents;

Photo, C. R. Toothaker, Phila. Commercial Museum.

Pitch Cones on Edge of Trinidad Lake.

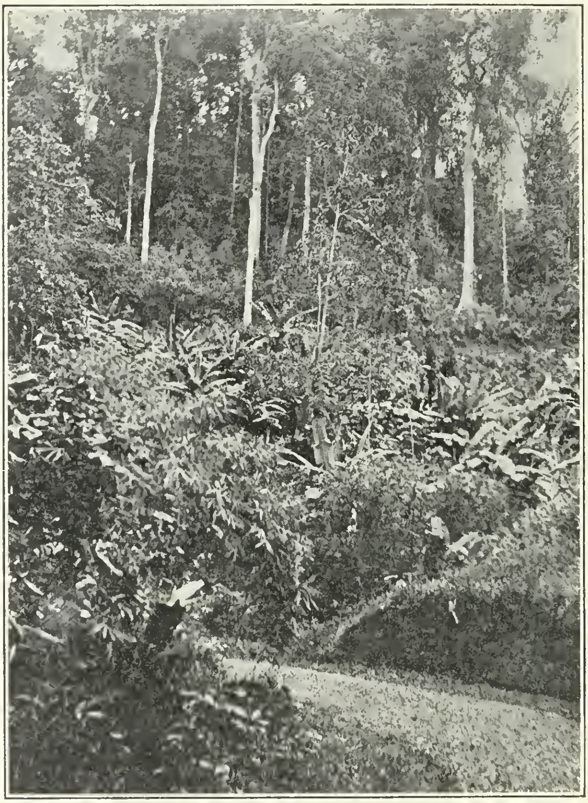
those which are soluble in light petroleum naphtha, and the remainder which are insoluble, although the percentage will depend to a certain extent on the character of the solvents. The softer or oily portion which is soluble in naphtha is, for 88° naphtha at air temperatures, about 63 per cent. The components of Trinidad asphalt and of other bitumens, which are thus soluble, have been denominated by the writer "Malthenes," a name to be applied to this class of hydrocarbons, not as representing any homogeneous entity, but merely descriptive of their general character. The term petrolenes has also been used to cover this same class of material.

Photo, C. R. Toothaker, Phila. Commercial Museum.

Plantation Buildings, Trinidad.

The hydrocarbons and their derivatives which are insoluble have been called asphaltenes.

The malthenes of Trinidad asphalt are distinguished by the fact that they are of an extremely sticky and cementitious nature, and not merely oily as is often the case with material of similar consistency prepared from petroleums. The value of any bitumen or combination of bitumens for highway construction depends on the character of the malthenes of which it is composed, and the relative proportion of these to the asphaltenes. Where the former are not present in sufficient amount, it is necessary to add to the asphalt material in which malthenes predominate to attain a proper consistency. This is known as fluxing the asphalt, and in the case of that of Trinidad, owing to the presence of the large amount of malthenes of a sticky nature, it can be accom-



Photo, C. R. Toothaker, Phila. Commercial Museum.

High Woods, Trinidad.

source of bitumen. Long before the asphalt was used on any industrial scale, attempts to reach this and obtain petroleum were made. A comparatively shallow well was sunk not far from the lake, and a heavy liquid asphalt was discovered, but the facilities available at that time for sinking a deep well, and the lack of demand or means of utilizing this material, caused development to be abandoned. Success has now crowned the efforts to obtain this liquid asphalt in commercial quantities, and it is now available for road construction. It has proved to be a most remarkable and unique form of bitumen. Primarily it is, of course, a petroleum, being a liquid form of bitumen coming from a depth of about 900 feet below the surface. Its characteristics as determined by the usual form of distillation proposed by Engler, and generally followed by oil experts, appears from the following data:

Specific gravity at 60° F.	.965
Beaume at 60° F.	15.1°
Flash—open cup	95° F.

Bitumen sol. in CS_2	99.9 per cent.
Bitumen insol. in 88° naphtha	8.3 per cent.
Loss 5 hours 325° F. (20 grams)	24.6 per cent.
Condition of residue	Fluid
Paraffine	None
Viscosity—Engler—212° F.—50 c.c.	34.5 sec.

Engler Distillation

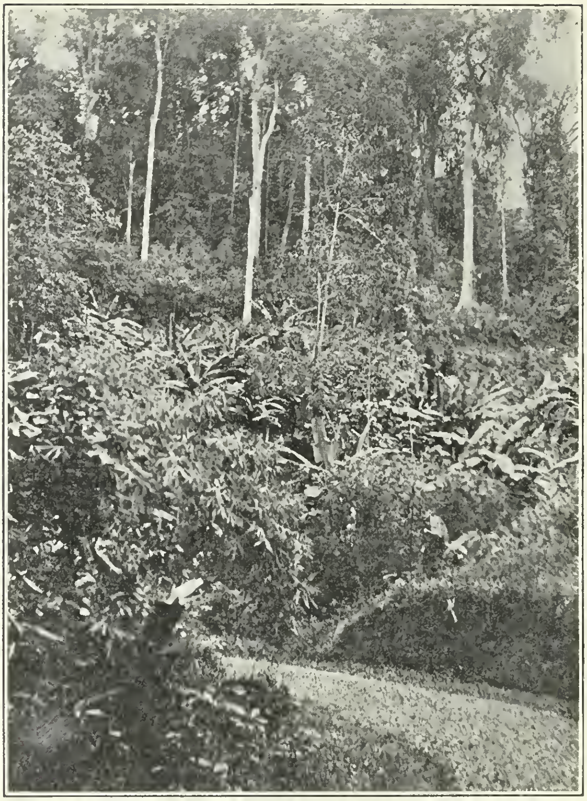
Below 302° F.	4.43 per cent.
302–520° F.	20.74 per cent.
Residue above 520° F.	74.53 per cent.
Loss	.30 per cent.
	100.00

This petroleum is truly asphaltic and carries no solid or heavy liquid paraffine hydrocarbons. It is distinguished by the fact that it yields a high percentage of light distillates or "tops" for an oil of such low gravity. The intermediate distillates, those of the lubricating type, are small in amount, while the residue is truly asphaltic resembling that found in the lake deposit, but of course free from mineral matter and water. On this account the oil is peculiarly adaptable to road surfacing work, the light oil carrying the heavier asphaltic portion into the surface and afterwards, on its evaporation under the sun, leaving it there in a most desirable form as a binding agent. If the lighter fraction or "tops" are removed, we have at once an asphaltic oil which is of the most desirable character for hot application, and has the following characteristics:

Specific gravity at 60° F.	.994
Beaume at 60° F.	10.8°
Flash—open cup	200° F.
Bitumen sol. in CS_2	99.9 per cent.
Bitumen insol. in 88° naphtha	10.8 per cent.
Loss 5 hours 325° F. (20 grams)	17.5 per cent.
Condition of residue	Fluid
Paraffine	None
Viscosity—Engler—212° F.—50 c.c.	102.2 sec.

The oil is further distinguished by the fact that it carries a very considerable percentage of sulphur, in the neighborhood of 3 per cent. and it is evident that the sulphur found in the Trinidad crude asphalt is derived, at least in part, from this source. Owing to the presence of this sulphur the oil possesses those desirable characteristics, as a road oil, which the refined Trinidad asphalt possesses as a paving material, and it is for this reason that a road carpet prepared with this liquid asphalt does not become unpleasantly soft when exposed to the sun.

(To be concluded)



Photo, C. R. Toothaker, Phila. Commercial Museum.

HIGH WOODS, TRINIDAD.

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(*To be concluded*)

THE RÔLE OF THE HOUSE FLY AND CERTAIN OTHER INSECTS IN THE SPREAD OF HUMAN DISEASES[1]

By W. E. BRITTON, Ph.D.

STATE ENTOMOLOGIST, NEW HAVEN, CONN.

THE rapid progress during recent years in the knowledge and treatment of human diseases has been marked by a number of discoveries so important and fundamental in their nature that intelligent people everywhere are paying homage to the discoverers, some of whom have given the best part of their lives for the benefit of others. In no line of scientific activity are the results of recent discovery more far-reaching or have they a more important bearing on the daily lives of men, women and children than in medical entomology—or the relation of insects to the transmission of human diseases.

The diseases that may be spread by insects are of course those that are commonly known as germ diseases, some of which are regarded as contagious or infectious. They are in some cases blood diseases, and affect the entire system, while in others perhaps only one part of the body, or certain organs, are involved. Some, like typhoid fever and tuberculosis, are caused by bacteria, the lowest forms of plant life, and others, like scarlet fever and malaria, by protozoa, which are animals low in the scale of classification. It is manifestly impossible in this paper to place before you all of the evidence, or even brief descriptions of the various studies and experiments which enabled the investigators finally to obtain the facts that make up our present knowledge of the subject. I shall therefore mention only a few of the strategic points and striking illustrations, hoping that these may be sufficient to show the importance of the subject and the necessity for action, and to enlist your interest in it.

The agency of insects in the spread of human diseases is of two sorts—(1) mechanical carriers, (2) essential hosts.

To the first group belongs the common house fly, and whatever germs adhere to the body, feet, tongue or wings of the fly in its perambulations in and over filth, or those that are swallowed by it, may be deposited on food or in other places in such manner as to cause infection.

The mosquito is a good example of the second group. One species, *Anopheles maculipennis*, is one of the necessary hosts in the development of the malarial parasite. Man is the other host, and in the blood

[1] This paper in substance was given, with lantern slides, before the Consumers' League, New Haven, Conn., May 4, 1911. A few paragraphs are taken verbatim from previous papers by the author.

of each host the parasite undergoes a certain development which is essential to complete the life cycle and insure the perpetuation of the malarial organism. Another kind of mosquito, in the tropics, is responsible in a similar manner for infecting human beings with yellow fever.

With these brief introductory remarks, we will now take up a discussion of the house fly and such other insects as are known to carry disease germs.

The House Fly, *Musca domestica*

The common house fly has been associated with typhoid epidemics so frequently during the past few years that Dr. Howard suggests that it be called the "typhoid fly." [2] Even before the rôle of this insect was definitely understood, it was suspected to have a connection with the disease, because typhoid fever is generally most prevalent in late summer, at the time when flies are the most abundant. I do not wish to convey the impression that typhoid is spread only by means of flies, for such is not the case. There are plenty of other agencies, such as a polluted water or milk supply, but flies play a much more important part in this connection than was supposed a few years ago, and the house fly is more important than other species because of its great abundance and its habit of occupying the dwellings of man and crawling over his food.

It was an old idea that flies were not only innocuous but were a benefit to mankind. It is said that Sir John Lubbock provoked a laugh in the House of Commons in 1873 by quoting as follows from one of the books used in the elementary schools: "The fly keeps the warm air pure and wholesome by its swift and zigzag flight." [3]

On the other hand, Kircher,[4] writing in 1658, makes the following statement: "There can be no doubt that flies feed on the internal secretions of the diseased and dying, then flying away, they deposit their excretions on the food in the neighboring dwellings, and persons who eat it are thus infected."

As it took 240 years to demonstrate the truth of this theory, and as twelve years have now passed, and the lesson of the Spanish war has not yet come into general practise, it is a mooted question if, after all, our progress is not an idle boast. At the present day there are many persons who regard flies as a necessary nuisance, but who are not awake to the dangers of their abundance.

As a rule flies do not go far from their breeding places, and if they are very abundant in any locality it is reasonably certain that their breeding place is close at hand.

[2] L. O. Howard, Bureau of Entomology, Bull. 78, p. 23.

[3] G. H. F. Nuttall, Johns Hopkins Hospital Reports, Vol. VIII., p. 37.

[4] W. A. Riley, *Science*, February 18, 1910.

The house fly does not bite, but its mouth parts are fitted for lapping and sucking up liquids. Another fly (*Stomoxys calcitrans*), called the stable fly, pierces the skin, and as this fly resembles the house fly and sometimes enters houses, many persons are mistaken in thinking that the house fly actually bites.

Breeding in filth and visiting all sorts of foul waste and decaying animal and vegetable matter and crawling over it, flies can not help becoming contaminated. At the first opportunity they will also crawl over food in the kitchen and drink from the milk pitcher. In this way some of the germs are rubbed off and adhere to the food and are swallowed with it by human beings. The diseases most commonly disseminated in this manner are those of the alimentary canal known as enteric diseases, such as typhoid fever, cholera and dysentery, the germs of which are voided in fecal matter, which if left exposed is certain to be visited by hundreds of flies, and some of the causative bacterial germs of these diseases are thus transferred to food, and infection is thus made possible. But it is not these diseases alone that may be and are occasionally carried by flies. There is considerable evidence to show that the house fly and its near relatives may carry the anthrax bacillus in their digestive systems and deposit the germs with their excretions, or may carry these germs exteriorly if the flies have visited foul matter containing them. They may then infect persons by crawling over wounds or even food. Flies may carry the germs of tuberculosis by visiting sputum and then crawling over the mouth and nose and food of persons. Nuttall made some interesting experiments in 1897 which proved that house flies not only may carry the germs of bubonic plague, commonly carried by fleas, but that they may actually die of the disease.[5]

It has been shown that the causative germs of some of these diseases may be and are taken into the digestive tract of the house fly and deposited upon food, confections or other substances. Thus the tiny fly specks which are the bane of every good housekeeper may be positively dangerous.

Formerly it was supposed that the house fly bred only in manure from the stables, and that it did breed in such places was pointed out as early as 1834 by Bouché. In 1873 Packard, and in 1880 Taschenberg, published accounts of the house fly showing that it usually breeds in horse manure. Packard records fourteen days as the period required to develop a generation. Dr. Howard in 1895[6] studied the insect, and had some difficulty in rearing it in captivity. The female laid 120 eggs, which hatched in eight hours, and the maggots lived five days before transforming. The pupa or cocoon stage also lasted five

[5] G. H. F. Nuttall, Johns Hopkins Hospital Reports, Vol. VIII., p. 16.

[6] L. O. Howard, Bureau of Entomology, Bull. 4, p. 46, 1896.

days, making only ten days for the complete life cycle. Dr. Howard considered that probably ninety-five per cent. of all house flies in towns and cities breed in the heaps of horse manure about the stables or in the fields. Later investigations of Dr. Howard and others show that the house fly may breed in privies, garbage cans and garbage heaps, street sweepings, waste from slaughter houses, and even between the folds of old paper from ash dumps. In fact, in almost any place where suitable moisture and food conditions exist.

Notable Typhoid Epidemics

The thoughtlessness of some persons having charge of the sick is described by Dr. Veeder in the New York *Medical Record*.[7] He states that he has seen dejecta from a typhoid patient emptied from a commode and the receptacle left standing without disinfection within a few feet of a pitcher of milk, both attracting flies, which fairly swarmed from one to the other. In the summer of 1898, when our armies were in camp in the southern states during the Spanish war, an epidemic of typhoid broke out. It caused much apprehension and cost many lives. Though the water supply was suspected, the authorities were not able to check the disease by the methods usually practised. Dr. Veeder was one of the first to advance the idea that the germs were being carried by flies, and it was not until the camp had been visited by government entomologists from Washington that the matter was properly controlled. I have the statement from a young soldier who at Chickamauga contracted the disease and was carried to a Philadelphia hospital for treatment, that the sinks or latrines had become filled to overflowing, and were not even covered with dirt, but, reeking with filth and disgusting odors, they attracted vast swarms of flies. It was but a short distance to the mess tents, where flies swarmed just as thickly, and during the investigation that followed, flies were taken from the food with their legs whitened by the lime that had been spread over the sinks. Thousands of soldiers were then encamped, hundreds were sick with typhoid, yet the able men had little or nothing to do, and might just as well have kept the camp in a sanitary condition. It appeared afterwards that the sanitary regulations of the surgeon general had not been followed: the privates dared not complain, the officers in charge were indifferent to this phase of the sanitation of the camp, and the surgeons were all busy administering to the sick and wounded. Such a condition is especially dangerous in view of the fact that in typhoid cases the germs are often given off in the dejecta before the disease has been recognized and before the patient takes to the bed, and also for a long time after recovery seems complete.

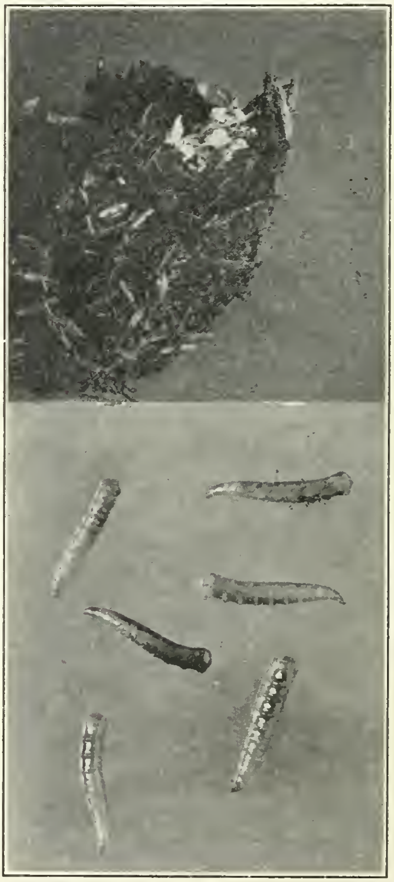
Permit me to quote from the official report of Messrs. Reed, Vaughan

[7] H. A. Veeder, New York *Medical Record*, Vol. 54, September 17, 1898.

Common House or Typhoid Fly, *Musca domestica*. Enlarged five times. Eggs as they are deposited in horse manure. Natural size.

and Shakespeare, who were appointed to investigate this typhoid outbreak:

"About one fifth of the soldiers in the National Encampment in the United States in 1898 developed typhoid fever." "The percentage of deaths among typhoid fever cases was 7.61." "The deaths from typhoid fever were 86.24 per cent. of the total deaths." "Flies undoubtedly serve as carriers of the infection."[8]



Puparia and Maggots or Larvæ of House Fly. Enlarged three times.

In other words, out of 107,-973 officers and men in the camps, 20,738 were sick and 1,578 died from typhoid. From the above figures it is evident that flies are more effective destructive agents than Spanish bullets.

According to Dr. Alice Hamilton,[9] the Chicago typhoid epidemic of 1902 was traced largely to the agency of flies.

[8] Walter Reed, V. C. Vaughn, E. O. Shakespeare, "Report on the Origin and Spread of Typhoid Fever in U. S. Military Camps during the Spanish War of 1898," p. 666.

[9] Hamilton, *Journal of American Medical Association*, 40, 576.

One of the most significant publications in recent years was issued in 1908 by the Merchants' Association of New York City on the pollution of New York Harbor.[10] The fecal matter of the sewerage discharge into the water attracted swarms of flies, many of which were caught in traps placed on the piers and afterward examined in the laboratory for bacteria. One individual fly carried more than 100,000 fecal bacteria. The same publication contains a chart showing the location where each individual death from intestinal diseases occurred during the season, and they were by far the most prevalent in the downtown districts near the water front, where sewerage and fly conditions are worst. Infantile diarrhœa was the cause of many of these deaths, and the author of this publication, Dr. Jackson, attributes much of the infection to the agency of flies.

Washburn only last year[11] investigated a typhoid outbreak, and found flies chiefly responsible for the spread of this disease on the Iron Range of Minnesota. Many other cases might be cited.

Local Conditions to be Avoided

Many persons go from their homes in the cities to spend their vacations at shore resorts or mountain camps, and are soon taken sick with typhoid. The imperfect sanitary conditions at many of these places make it hard to prevent the spread of the disease if a case of it occurs, and where a large number of persons are brought together from different localities there is always danger.

Large gangs of laborers in quarries, lumber camps and on construction work are, on account of carelessness and ignorance, liable to suffer from the spread of typhoid fever by flies, and what has been said of typhoid would doubtless be equally true of cholera and dysentery.

In looking about our cities and towns for breeding places of the house fly, what do we find? In many stables manure is allowed to accumulate untreated as long as there is room for it, then it is carted away to the suburbs and piled upon the land. Carloads of manure from the large cities are drawn through our towns and allowed to stand on sidings for several days, perhaps, before reaching their destination and being unloaded. Streets are often so filthy as to attract flies, and when cleaned, the sweepings are dumped on vacant lots or drawn into the parks for fertilizer and allowed to remain in heaps several months. In many streets water closets are not installed, and uncared-for dry closets are still in use. All of these conditions are favorable for the breeding of flies, and we should remember that in

[10] D. D. Jackson, "Pollution of New York Harbor," Merchants' Association of New York, July, 1908.

[11] F. L. Washburn, Report of State Entomologist of Minnesota, 1909–1910, p. 135. See also Popular Science Monthly, August, 1911, p. 137.

UNLOADING A CAR OF STABLE MANURE FROM NEW YORK. Four ounces of material from the top of this carload contained between 700 and 800 maggots, by actual count.

warm weather only ten days are required to develop a generation. Each female may lay 120 eggs, and her possible progeny amounts to more than 3,000,000,000 in a single season. Hence the tremendous increase in the number of flies the latter part of the summer. Then please visit some of our cheap restaurants and meat markets, and note how they are swarming with flies which crawl all over the unprotected food and provisions. If you must eat food from such a place, choose something that can be cooked thoroughly before eating, or if raw, something that has a natural covering to be removed before eating, like an orange or banana. Remember that typhoid fever does not always come through the water or milk supply or by eating oysters.

Of course flies do not originate typhoid fever, but if a case occurs in a locality where conditions are unsanitary they are sure to spread it.

The stable manure which is shipped in carloads from the cities to suburban or country districts is an excellent breeding place for flies. Two years ago one of my assistants examined such a loaded car standing upon the siding near this city (New Haven). The contents had come from New York and was waiting to be unloaded for use upon the land for growing fruit or vegetable crops. The upper two inches of the manure was literally swarming with maggots. Some of the material was taken to the laboratory, and four ounces of it contained between 700 and 800 maggots, by actual count!

What of ordinances and health board regulations? It is true that anti-spitting rules are in force, as are also regulations about the covering of foodstuffs when carted through the streets or exhibited for sale, and garbage cans and wagons must be covered. Is it unreasonable to

require that exposed surfaces of manure on platform cars or in stables, yards and fields be either screened or treated once a week to prevent the breeding of flies?

Remedies for Flies

Screen buildings: and prevent flies from breeding.

All living rooms in houses, and especially the kitchen and dining room, sick-rooms, and all hotels, restaurants, markets and stores where food supplies are sold or stored should be fitted with screens to keep out flies.

Breeding places of flies should be abolished where possible by not allowing manure, garbage or filth to accumulate or by screening it to keep flies away, or by treating it to kill the maggots. Manure treated with chloride of lime each day will not produce flies. Kerosene or one of the so-called soluble or miscible oils sold everywhere for spraying orchards will probably kill the maggots if the outer two inches is saturated with the liquid.

Flies in houses may be killed by the use of insect powder, fly-paper, or by five-per-cent. sweetened formalin placed about the rooms in saucers. A recent circular[12] from the North Carolina Agricultural Experiment Station recommends one tablespoonful of commercial formalin (40 per cent.) to a half pint teacup of half milk and half water. The liquid is exposed in a shallow plate with a slice of bread in it to give more space for the flies to alight while drinking. The author of this circular, Professor R. I. Smith, states that in this way

Horse Manure piled in the Suburbs, in a suitable condition to breed many flies.

[12] R. I. Smith, Press Bulletin No. 23. North Carolina Agricultural Experiment Station.

he has killed over 40,000 flies (about four quarts) inside of twenty-four hours in a barn where flies were very numerous.

Other Flies that Carry Diseases

The terrible scourge of Africa known as sleeping sickness is caused by a protozoan parasite known as *Trypanosoma gambiense,* and is transmitted by the bite of a species of fly, *Glossina palpalis.* In our own southern states the disease known as "pink eye" is disseminated by a minute fly of the genus *Hippelates.*

View of an Ill-kept City Stable Yard, showing a manure heap where thousands of house flies breed.

Mosquitoes and Malaria

Malaria has been known ever since 400 B.C. in southern Europe,[13] and from the records it must have been present in Connecticut for about 250 years, though not generally distributed here, nor did it appear in the form of an epidemic until about 1860, when it broke out in the southwestern corner of the state and spread gradually during the next twenty years until the entire area of the state was involved. It is thought that soldiers returning from the Civil War brought it from the south.

The cause of malaria was formerly thought to be gases or foul emanations from swamps, and it was in 1881 that Laveran, a French army surgeon, discovered in the red corpuscles of human blood a protozoan parasite, which he named *Plasmodium malariæ.* Though the mosquito was suggested by King in 1882 as a possible agent in trans-

[13] L. O. Howard, Bureau of Entomology, Bull. 78, p. 37.

mitting this disease, it remained for Dr. Patrick Manson, of London, to point out in 1895 that the malarial parasite had an alternate mode of generation, and he considered some blood-sucking insect (probably a mosquito) as the most probable host. His pupil, Dr. Ronald Ross, an English military surgeon, soon went to India, and after patiently dissecting the bodies of hundreds of mosquitoes, finally discovered one having pigmented bodies in the stomach after biting a malarial patient. In 1900, Sambon and Low, and Grassi, conducted in the most malarious sections of Italy careful experiments which proved to the world that malaria is transmitted to man through the bites of the malarial mosquito, *Anopheles maculipennis.* These experiments have since been duplicated and the results confirmed by many others in different parts of the world.

Mosquitoes breed only in water, and the malarial mosquito will breed in almost any pool where other kinds flourish, but is never so abundant as the rain-barrel mosquito, *Culex pipiens,* or the salt-marsh mosquito, *Culex sollicitans.* It lays its eggs singly on the surface of the water. They hatch in a few hours, and the young larvæ or wigglers feed in the water on minute particles of vegetable matter. Each larva goes to the surface every few minutes to inhale air through the tube or siphon near the tail. In a few days the wiggler changes to a peculiar hunchback pupa, and the adult mosquito emerges two or three days later. Only a week is required in warm weather to complete the life cycle.

As a rule, mosquitoes do not fly far, and usually breed in the vicinity where they occur. The salt marsh mosquito is an exception to this rule, and often flies inland for twenty-five or thirty miles, though it breeds only near the coast.

From the records of the State Board of Health it appears that for the decade ending with 1903, 1,073 deaths, or more than 100 each year, occurred in Connecticut from malarial diseases alone. Dr. Howard obtained similar figures from those states where statistics are kept (less than one half of the states keeping them, and these being in the north), which show that more than 12,000 deaths occurred in eight years from malaria. From the records of a number of cities it appears that two deaths occur from malaria in the south to one in the north, and on this basis and including the non-registration states, he concludes that the annual death rate from malaria in the United States must amount to 12,000, and that it would be 96,000 for the eight-year period.[14]

But with malaria perhaps more than with any other disease the death rate is a small indication of the economic loss suffered. Many

[14] L. O. Howard, "Economic Loss to the People of the United States through Insects that Carry Disease." Bureau Entomology, Bull. 78, p. 10.

are ill for years from malaria, and their capacity for work greatly reduced, and they may finally die from some other trouble.

Yellow Fever and Mosquitoes

As early as 1881, Dr. Charles Finlay, of Habana, noticed a correspondence between the abundance of mosquitoes and the prevalence of yellow fever, but it was not until 1900, when our soldiers occupied the island of Cuba at the time of the Spanish War, that experiments were conducted proving that the disease is transmitted chiefly if not wholly by a mosquito, *Stegomyia calopus*. The investigating committee was appointed by Surgeon General Sternberg, and consisted of Messrs. Reed, Lazear, Carroll and Agramonte.

A small house was built and effectually screened against the entrance of all mosquitoes. A circulation of air was also prevented and all sunlight excluded. A temperature of 76.20° F., with a moist air, was maintained for sixty-three days—just the conditions favorable to the spread of bacterial diseases. Moreover, clothes, blankets and bedding which had been used by yellow fever patients and not cleaned were put into the building and used by the inmates. Seven non-immunes were kept in this house, two or three sleeping in one room with the contaminated bed-clothing, for about twenty nights, then shifts were made and other subjects placed under the same conditions. All seven were released from quarantine in excellent health at the end of sixty-three days, not a single case of yellow fever appearing. Formerly, contaminated clothing, bedding, etc., were regarded as a dangerous source of infection and were usually burned.

Another similar building was erected by these investigators and was divided into two large rooms, one admitting air and sunlight freely and containing the mosquitoes which had previously bitten yellow fever patients. In this room six out of seven persons bitten came down with yellow fever. From the other room mosquitoes were excluded, and the occupants remained in perfect health. These tests still more strongly confirmed previous experiments implicating the mosquito in transmitting yellow fever, and acting on this knowledge General Wood issued orders requiring the use of mosquito bars at the barracks and for the destruction of mosquito larvæ in the breeding pools by the use of petroleum. This work, in charge of Colonel Gorgas, was carried out thoroughly, and continued until Habana was a comparatively healthy city. Mosquito extermination has everywhere been practised—fumigating buildings with tobacco or sulphur to kill the adults, and draining and filling the pools or applying oil to kill the larvæ or wigglers. Of 26,000 of these mosquito breeding places within the city limits in March, 1901, only 300 remained in January, 1902.[15] More-

[15] W. C. Gorgas, "A Few General Directions with Regard to Destroying Mosquitoes." Government Printing Office, Washington, D. C., 1904.

over, the number of deaths from malaria in Habana was greatly reduced from 325 in 1900 to 151 in 1901, 77 in 1902, and 45 up to the first of November, 1903.

In 1905, yellow fever broke out in New Orleans. The situation was critical, and on August 12 was placed under the control of the Public Health and Marine-Hospital Service under Dr. White. A warfare against the yellow-fever mosquito was at once commenced. This mosquito was found breeding in the rain-water cisterns which abounded in the city. These cisterns were screened, and various pools treated. The epidemic abated at once, and the total number of deaths was 460 as against 4,046 in the epidemic of 1878, 4,858 in 1858, and 7,848 in 1853.

Similar control measures have been inaugurated in the Panama Canal zone, with the result that the canal is soon to be completed and the region is now considered fairly salubrious, though the French had to abandon their work there on account of the unhealthy climate.

Measures for Controlling Mosquitoes

Mosquito prophylaxis is usually an engineering problem pure and simple—abolish breeding places. This can be done in nine out of ten cases by filling and draining at small expense. In the tenth case it may be advisable, on account of expense, to make a permanent pool and stock it with carnivorous fishes. The edges should be deep and abrupt, and kept clean and free from vegetation. In the salt marshes, ditches should be opened so that the tide may ebb and flow through them, and mosquitoes will not breed there. Fill all small depressions.

Screen all houses, and also screen all cisterns and rain-water barrels to keep mosquitoes out of them. Treat the surface of all breeding places once each ten days with oil to prevent the breeding of mosquitoes therein until these pools can be made permanently safe.

Fleas and Plague

Bubonic plague, or "black death," has always been one of the most dreaded diseases of mankind, and from the scourge of Egypt, beginning about A.D. 542 and lasting sixty years, down to the San Francisco epidemic of 1907–08, communities and government authorities have been powerless to cope with it. In India even at present, according to the newspapers, the mortality from this disease was 43,508 for the month of February and 95,884 for March, 1911. As it has always been serious in India, various commissions there and in other countries have each investigated and made their own contributions toward a knowledge of the disease. From 1896 to 1903, during these investigations, it was learned that the bacterial germ *Bacillus pestis*, causing the disease, entered through some wound, puncture or abrasion of the skin, and that all fleas and bugs sucking the blood of dying plague-diseased ani-

mals contained plague microbes. Fleas attacking rats were then suspected, and experiments proved that they were capable of transmitting the disease to human beings. Rats and ground squirrels die in large numbers from the plague,[16] which is said to be primarily a disease of rats.

So, working in the light of the knowledge previously gained, Dr. Blue, of the Public Health and Marine Hospital Service, in charge of the outbreak of plague in San Francisco in 1907, directed the warfare against rats, killing more than a million in the city, and disinfecting them as soon as they could be caught. At first the work was difficult. Cases of plague were kept secret. The prejudices of ignorance and superstition had to be overcome. City officials as well as the people had to be educated, and laws made and enforced. But the work was finally performed so thoroughly that San Francisco made a new record in sanitation, and only about 140 cases developed. Except for this effective campaign not only San Francisco and California were endangered, but the whole country imperiled.[17]

Remedial Measures

Destroy all rats by the use of baited traps and poisons, dipping them immediately in a solution of corrosive sublimate to disinfect them. This immediately kills the rats and the fleas, with the plague germs on them.

Fumigate buildings to kill fleas and disease germs.

Build solid concrete foundations, floors and walls where possible in buildings and wharves to keep out rats.

Other Diseases that are Known or Thought to be Transmitted by Insects

There are certain other diseases, mostly tropical, that are known to be carried by insects, and still others that are believed to be similarly transmitted, though the connecting evidence forming the proof is not yet complete. Elephantiasis is caused by worm-like parasites transmitted through the bites of certain mosquitoes of the genus *Culex* in the East and West Indies. Dengue fever and malta fever are probably disseminated by mosquitoes.

It is thought that the germs of leprosy are transmitted by the bites of mosquitoes, flies, fleas, lice. mites or bedbugs. Dr. Patton, of the Indian Medical Service, has demonstrated that the fatal and infectious tropical disease called "kala-azar" is transmitted by the bites of the

[16] R. W. Doane, "Insects and Disease," p. 155.

[17] Report of Citizens' Health Committee, "Eradicating Plague in San Francisco."

[18] R. W. Doane, "Insects and Disease," p. 173.

Indian bedbug, *Cimex rotundatus*.[18] Our bedbug, *Cimex lectularius*, which has always been in disrepute, though constantly appearing in the best society, is now under suspicion. It is not only possible, but quite probable, that in the near future further discoveries will show that some other infectious diseases, like infantile paralysis, and possibly smallpox and scarlet fever, may be transmitted through the bites of some of the common insect parasites of man.

Pestilences were formerly considered as visitations of Providence to punish man for his wickedness. People were powerless to save their own lives or the lives of their friends. Ignorance and superstition are hard to overcome, but in the light of our present knowledge these scourges which I have mentioned are all preventable by controlling the little insects which carry the germs. Is it not therefore a crime to allow them to be repeated?

If the exact history of the world could be written and the truth revealed, it would be interesting to learn whether the decline of Greece was due largely to malaria, as Dr. Ross has suggested,[19] and also to find out how important a part these seemingly insignificant insects have played in shaping the destinies of the nations.

[19] L. O. Howard, Bureau of Entomology, Bull. 78, p. 36.

HOLES IN THE AIR

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THE bucking and balking, the rearing, plunging and other evidences of the mulish nature of the modern Pegasus soon inspired aerial jockeys to invent picturesque terms descriptive of their steeds and of the conditions under which their laurels were won or lost. One of the best of these expressions, one that is very generally used and seems to be a permanent acquisition, is "holes in the air." There are, of course, no holes in the ordinary sense of the term in the atmosphere—no vacuous regions—but the phrase "holes in the air" is brief and elegantly expressive of the fact that occasionally at various places in the atmosphere there are conditions which, so far as flying is concerned, are mighty like unto holes. Such conditions are indeed real, and it is the purpose of this paper to point out what some of them are, when and where they are most likely to occur and how best to avoid them.

Suppose for a moment that there was a big hole in the atmosphere, a place devoid of air and of all pressure. The surrounding air would rush in to fill this space with the velocity pertaining to free particles of the atmosphere at the prevailing temperature; that is to say, at the

velocity of sound in air at the same temperature, and therefore, at ordinary temperature, of about 1,100 feet per second, or 750 miles per hour. Even then, if such a hole existed, it would be impossible for an aeronaut to get into it—he couldn't catch up with it.

But, according to the claims of some, if there are no complete holes in the atmosphere there are, at any rate, places where the density is much less than that of the surrounding air; so much less indeed that when an aeroplane runs into one of them it drops quite as though it was in a place devoid of all air and without support of any kind.

This too, like the actual hole, is a pure fiction that has no support in barometrical records. Indeed, such a condition, as every scientific man knows, could be established and maintained only by a gyration or whirl of the atmosphere, such that the "centrifugal force" would be sufficient to equal the difference in pressure, at the same level, between the regions of high and low density.

Appropriate equations can be written to express the balance between pressure gradient and centrifugal force in any sort of winds, and at any part of the world (it depends slightly upon latitude). Therefore it is possible with certain conditions given to compute the wind velocity, or with other conditions given to compute the pressure gradient. But in the present case numerical calculations are not necessary. We know that an elevation of half a mile, easily reached by any aeroplane, produces roughly a 10 per cent. decrease in pressure; and we know too that a greater pressure difference than this seldom exists even between center and circumference of violent tornadoes. Hence a drop in density, or pressure, to which the density is directly proportional, sufficient to cause an aeroplane to fall, would require a tornadic whirl of the most destructive violence. Now there were no whirlwinds of importance in the air, certainly none that could be called tornadoes, at the times and places where aeronauts have reported holes, and therefore even half holes, in the sense of places sufficiently vacuous to cause a fall, must also be discarded as unreal, if not impossible.

Along with these two impossibles, the hole and the half hole, the vacuum and the half vacuum, should be consigned to oblivion that other picturesque fiction,—the "pocket of noxious gas." Probably no other gases, certainly very few, have, at ordinary temperatures and pressures, the same density as atmospheric air. Therefore a pocket of foreign gas in the atmosphere would almost certainly either bob up like a balloon, or sink like a stone in water; it could not float in mid air. It is possible, of course, as will be discussed a little later, to run into columns of rising air that may contain objectionable gases and odors, but these columns are quite different from anything likely to be suggested by the expression, "pockets of gas."

The above are some of the things that fortunately, alike for those

who walk the earth and those who fly the air, do not exist. We will now consider some of the things that do exist and produce effects such as actual holes and half holes would produce—sudden drops, and occasional disastrous falls.

Aerial Fountains

A mass of air rises or falls according as its density is less or greater respectively than that of the surrounding atmosphere, just as, and for the same reason that a cork bobs up in water and a stone goes down. Hence warm and therefore expanded and light air is buoyed up whenever the surrounding air at the same level is colder; and as the atmosphere is heated mainly through contact with the surface of the earth, which in turn has been heated by sunshine, it follows that these convection currents, or vertical uprushes of the atmosphere, are most numerous during warm clear weather.

The turbulence of some of these rising columns is evident from the numerous rolls and billows of the large cumulus clouds they produce, and it is obvious that the same sort of turbulence, probably on a smaller scale, occurs near the tops of those columns that do not rise to the cloud level. Further, it is quite possible, when the air is exceptionally quiet, for a rising column to be rather sharply separated from the surrounding quiescent atmosphere, as is evident from the closely adhering long columns of smoke occasionally seen to rise from chimneys.

The velocity of ascent of such fountains of air is, at times, surprisingly great. Measurements on pilot balloons, and measurements taken in manned balloons, have shown vertical velocities, both up and down, of as much as 10 feet per second. The soaring of large birds is a further proof of an upward velocity of the same order of magnitude, while the fact that in cumulus clouds water drops and hailstones often are not only temporarily supported, but even carried to higher levels, shows that uprushes of 25 to 30 feet per second not merely may but actually do occur.

There are, then, aerial fountains of considerable vertical velocity whose sides at times and places may be almost as sharply separated from the surrounding air as are the sides of a fountain of water, and it is altogether possible for the swiftest of these to produce effects more or less disconcerting to the aeronaut. The trouble may occur:

1. On grazing the column, with one wing in the rising and the other in the stationary air; a condition that interferes with lateral stability, and produces a sudden shock both on entering the column and on leaving it.

2. On plunging squarely into the column; thus suddenly increasing the angle of attack, the pressure on the wings, and the angle of ascent.

3. On abruptly emerging from the column; thereby causing a

sudden decrease in the angle of attack and also abruptly losing the supporting force of the rising mass of air.

That flying with one wing in the column and the other out must interfere with lateral stability and possibly cause a fall as though a hole had been encountered, is obvious, but the effects of plunging squarely into or out of the column require a little further consideration.

Let an aeroplane that is flying horizontally pass from quiescent air squarely into a rising column. The front of the machine will be lifted, as it enters the column, a little faster than the rear, and the angle of attack, that is to say, the angle at which the wing is inclined to the horizon, will be slightly increased. This, together with the rising air, will rapidly carry the machine to higher levels, which, of itself, is not important. If, however, the angle of attack is so changed by the pilot as to keep the machine, while in the rising column, at a constant level, and if, with this new adjustment, the rising column is abruptly left, a rapid descent must begin—the half hole is met. But even this is not necessarily harmful. Probably the real danger under such circumstances arises from *over adjustments* by the aeronaut in his hasty attempt to correct for the abrupt changes. Such an adjustment might well cause a fall so sudden as strongly to suggest an actual hole in the air.

Rising columns, of the nature just described occur most frequently during clear summer days and over barren ground. Isolated hills, especially short or conical ones, should be avoided during warm still days, for on such occasions their sides are certain to be warmer than the adjacent atmosphere at the same level, and hence to act like so many chimneys in producing updrafts. Rising air columns occur less frequently and are less vigorous over water, and over level green vegetation, than elsewhere. They are also less frequent during the early forenoon than in the hotter portion of the day, and practically absent before sun rise, and at such times as the sky is wholly covered with clouds.

Aerial Cataracts

The aerial cataract is the counterpart of the aerial fountain, and is most likely to occur at the same time. It is seldom rapid, save in connection with thunder storms, and such effect as it may have is exactly similar to, but in the opposite direction from, that of the rising column.

Aerial Cascades

The term "aerial cascade" may, with some propriety, be applied to the wind as it sweeps down the lee side of a hill or mountain. It is most pronounced when the wind is at right angles to the direction of the ridge, and when the mountain is rather high and steep. The swift downward sweep of the air when the wind is strong may carry the aeroplane with it and lead observers, if not the pilot, to fancy that another

hole has been encountered, when of course, there is nothing of the kind. Indeed such cascades should be entirely harmless so long as the aeronaut keeps his machine well above the surface and therefore out of the treacherous eddies, presently to be discussed.

Wind Layers

It is a common thing to see two or more layers of clouds moving in different directions and at different velocities. Judgment of both the actual and the relative velocities of the cloud layers may be badly in error—the lower seems to be moving faster, and the higher slower, than is actually the case. Accurate measurements, however, are possible and have often been made.

These differences in direction and velocity of the winds are not confined to cloud layers, nor even to cloudy weather, as both pilot and manned balloons have often shown. Occasionally balloons float for long intervals with a wind in the basket, showing that the top and the bottom of the balloon are in currents of different velocities. Another evidence of wind layers moving with different velocities is the waves or billows so often seen in a cloud layer. A beautiful example of these cloud waves, both regular, when the directions are the same but the velocities different, and irregular, when the winds are more or less crossed, is shown in the accompanying picture, taken by Professor A. J. Henry, of the U. S. Weather Bureau, and kindly lent for this illustration.

It was explained by Helmholtz as far back as 1889 that layers of air differing in density are of frequent occurrence, and that they glide, sharply divided and with but little intermingling, the one over another in much the same manner that air flows over water, and with the same general wave-producing effect. These air waves are "seen" only when the humidity at the interface is such that the slight difference in temperature between the crests and the troughs is sufficient to keep the one cloud-capped and the other free from condensation. In short, the humidity condition must be just right, and therefore, though such clouds are often seen, air billows must be of far more frequent occurrence.

Consider now the effect on an aeroplane as it passes from one such layer into another. For the sake of illustration let the case be an extreme one. Let the propeller be at rest and the machine be making a straight away glide to earth, and let it suddenly pass into a lower layer of air moving in the same horizontal direction as the machine and with the same velocity. This of course is an extreme case, but it is by no means an impossible one. Instantly on entering the lower layer, under the conditions just described, all dynamical support must cease and with it all power of guidance. A fall, for at least a considerable distance, is absolutely inevitable, and a disastrous one highly probable. To all intents and purposes a hole, a perfect vacuum, has been run into.

The reason for the fall will be understood when it is recalled that, for all ordinary velocities, wind pressure is very nearly proportional to the square of the velocity of the wind with respect to the thing against which it is pressing. Hence, for a given inclination of the wings, the lift on an aeroplane is approximately proportional to the square of the velocity of the machine with reference, *not* to the ground, but to the *air* in which it happens to be at the instant under consideration. If then it glides, with propellers at rest, into air that is moving in the same horizontal direction and with the same velocity it is in exactly the condition it would be if dropped from the top of a monument in still air. It must inevitably fall to ruin, unless indeed rare skill in balancing or, possibly, mere chance should bring about a new glide after additional velocity had been acquired as the result of a considerable fall. Warping of wings, turning of ailerons, dipping and twisting of rudders, and all the other devices of this nature would be utterly useless at first, totally without effect so long as wind and machine have the same velocity, for, as already explained, there would be no pressure on them in any position and consequently nothing that could be done with them would at first have any effect on the behavior of the machine. However, as stated above, a skillful pilot may secure a new glide with a properly constructed machine, and finally, if high enough, make a safe landing.

Of course, such an extreme case must be of rare occurrence, but cases less extreme are met with frequently. On passing into a current where the velocity of the wind is more nearly that of the aeroplane, and in the same direction, more or less of the supporting force is instantly lost, and a corresponding drop or dive inevitable. Ordinarily, however, this is a matter of small consequence, for the new speed necessary to support the machine is soon acquired, especially if the engine is in full operation. Occasionally though the loss in support may be large and occur but a short distance above the ground, and therefore be distinctly dangerous.

If the new wind layer is against and not with the machine an increase instead of a decrease in the sustaining force is the result, and but little occurs beyond a mere change in the horizontal speed of the machine with reference to the ground, and a slowing up of its rate of descent.

Wind sheets, within ordinary flying levels, are most frequent during weather changes, especially as fine weather is giving way to stormy. This then is a time to be on one's guard against the most dangerous of all "holes in the air." It is also well to avoid making great changes in altitude since wind sheets, of whatever intensity, remain roughly parallel to the surface of the earth, and the greater the change in altitude the greater the risk of running into a treacherous "hole." Also,

lest there might be a wind sheet near the surface, and for other good reasons, landings should be made, if possible, squarely in the face of the *surface* wind.

Wind Billows

It was stated above that when one layer of air runs over another of different density billows are set up between them, as illustrated by the cloud picture. Of course, as above explained, the warning clouds are comparatively seldom present, and therefore even the cautious aeronaut may, with no evidence of danger before him, take the very level of the billows themselves, and before getting safely above or below them encounter one or more sudden changes in wind velocity and direction due, in part, to the eddy-like or rolling motion within the billows, with chances in each case of being suddenly deprived of a large part of the requisite sustaining force—of encountering a "hole in the air." There may be perfect safety in either layer, but, unless headed just right, there necessarily is some risk in going from the one to the other, and therefore, since flying at the billow level would necessitate frequent transitions of this dangerous nature, it should be strictly avoided.

Wind Eddies

Eddies and whirls exist in every stream of water, from tiny rills to the great rivers and even the ocean currents, wherever the banks are such as greatly to change the direction of flow and wherever there is a pocket of considerable depth and extent on either side. Similar eddies, but with horizontal instead of vertical axes, occur at the bottoms of streams where they flow over ledges that produce abrupt changes in the levels of the beds.

The inertia of the stream of water, its tendency to keep on in the direction it is actually moving and with unchanged velocity, together with its viscosity, necessitate these whirls with which nearly all are familiar. Similarly, and for the same general reasons, horizontal eddies occur in the atmosphere, and the stronger the wind the more rapid the rotation of the eddy. They are most pronounced on the lee side of cuts, cliffs and steep mountains, but occur also, to a less extent, on the windward side of such places.

The air at the top and bottom of these whirls is moving in diametrically opposite directions, at the top with the wind, at the bottom against it, and since they are close to the earth they may therefore, as explained under "wind layers," be the source of decided danger to aeronauts. There may be danger also at the forward side of the eddy where the downward motion is greatest.

When the wind is blowing strongly landings should not be made, if at all avoidable, on the lee side of and close to steep mountains, hills, bluffs or even large buildings; for these are the favorite haunts, as just

explained, of treacherous "holes in the air." The whirl is best avoided by landing in an open place some distance from bluffs and large obstructions, or, if the obstruction is a hill, on the top of the hill itself. If, however, a landing to one side is necessary and the aeronaut has choice of sides, he should, other things being equal, take the *windward* and not the *lee* side. Finally, if a landing close to the lee side is compulsory he should, if possible, head along the hill, and not toward or from it; along the axis of the eddy and not across it. Such a landing would be safe, unless made in the down draft, since it would keep the machine in winds of nearly constant (zero) velocity with reference to its direction, whatever the side drift, provided the hill was of uniform height and slope and free from irregularities. But as hills seldom fulfill these conditions lee side landings of all kinds should be avoided.

Aerial Torrents

Just as water torrents are due to drainage down steep slopes, so too aerial torrents owe their origin to drainage down steep narrow valleys. Whenever the surface of the earth begins to cool through radiation or otherwise the air in contact with it becomes correspondingly chilled and, because of its increased density, flows away to the lowest level. Hence of clear still nights there is certain to be air drainage down almost any steep valley. When several such valleys run into a common one, like so many tributaries to a river, and especially when the upper reaches contain snow and the whole section is devoid of forest, the aerial river is likely to become torrential in nature along the lower reaches of the drainage channel.

A flying machine attempting to land in the mouth of such a valley after the air drainage is well begun is in danger of going from relatively quiet air into an atmosphere that is moving with considerable velocity—at times amounting almost to a gale. If one must land at such a place he should head up the valley so as to face the wind. If he heads down the valley and therefore runs with the wind he will, on passing into the swift air, lose his support, or much of it, for reasons already explained, and fall as though he had suddenly gotten into an actual "hole in the air."

Aerial Breakers

The term "aerial breakers" is used here in analogy with water breakers as a general name for the rolling, dashing and choppy winds that accompany thunder-storm conditions. They often are of such violence, up, down and sideways in any and every direction that an aeroplane in their grasp is likely to have as uncontrolled and disastrous a landing as would be the case in an actual hole of the worst kind.

Fortunately aerial breakers usually give abundant and noisy warn-

ings, and hence the cautious aeronaut need seldom be, and, as a matter of fact seldom is, caught in so dangerous a situation. However, more than one disaster is attributable to just such winds as these—to aerial breakers.

Classification

The above eight types of atmospheric conditions may conveniently be divided into two groups with respect to the method by which they force an aeroplane to drop.

1. *The Vertical Group.*—All those conditions of the atmosphere, such as aerial fountains, cataracts, cascades, breakers and eddies (forward side), that, in spite of full speed ahead with reference to the *air,* make it difficult or impossible for an aeronaut to maintain his level, belong to a common class and depend for their effect upon a vertical component, up or down, in the motion of the atmosphere itself. Whenever the aeronaut, without change of the angle of attack and with a full wind in his face, finds his machine rapidly sinking, he may be sure that he has run into some sort of a down current. Ordinarily, however, assuming that he is not in the grasp of storm breakers, this condition, bad as it may seem, is of but little danger. The wind can not blow into the ground and therefore any down current, however vigorous, must somewhere become a horizontal current, in which the aeronaut may sail away or land as he chooses.

2. *The Horizontal Group.*—This group includes all those atmospheric conditions—wind layers, billows, eddies (central portion), torrents and the like—that, in spite of full speed ahead with reference to the *ground,* abruptly deprive an aeroplane of a portion at least of its dynamical support. When this loss of support, due to a running of the wind more or less with the machine, is small and the elevation sufficient there is but little danger, but, on the other hand, when the loss is relatively large, especially if near the ground, the chance of a fall is correspondingly great.

Conclusions

1. Holes in the air, in the sense of vacuous regions, do not exist.

2. Conditions in the atmosphere favorable to precipitous falls, such as would happen in holes, do exist, as follows:

a. Vertical Group

1. *Aerial Fountains.*—Uprushes of air, most numerous during warm clear weather and over barren soil, especially above conical hills, are disconcerting and dangerous to the novice, but do not greatly disturb an experienced aviator.

2. *Aerial Cataracts.*—Down rushes of air, like the up rushes with which they are associated in a vertical circulation, though less violent, must also be most frequent during warm weather when the ground is

strongly heated. They too, however annoying to the beginner, should not be dangerous to the experienced man, because even when strong enough to carry the machine down for a distance their descent necessarily becomes slow and their chief velocity horizontal before the surface is reached.

3. *Aerial Cascades.*—Rapid falls of air are found to the lee sides of hills and mountains, and the stronger the wind the more rapid the cascade. But they are of no danger to the aeronaut so long as he takes the precaution to keep above the eddies and other surface disturbances.

4. *Aerial Breakers.*—The choppy, breaker-like winds of thund r storms that surge up and down and in all sorts of directions are as much to be avoided by aerial craft as are ocean breakers by water craft. Hence a flight should positively not be attempted under any such circumstances.

5. *Wind Eddies (Forward Side).*—The air on the forward side of a strong eddy has a rapid downward motion and therefore should be avoided. If caught in the down current of an eddy the aeronaut should head lengthwise of the hill or mountain to which the eddy is due. By heading away from the mountain he might, to be sure, get entirely out of the whirl, but the chances are just as great that instead of getting out he would only get the deeper in and encounter downward currents of higher speed.

b. Horizontal Group

1. *Wind Layers.*—The atmosphere is often made up of two or more superimposed layers moving each with its own velocity and direction. Such a condition is a source of danger to the aeronaut because transition from one of these layers to another more nearly coincident in direction and velocity with his aeroplane is certain to result in a sudden decrease in the magnitude of its supporting pressure and in the effectiveness of the balancing devices. Under certain extreme conditions this transition is well nigh inevitably disastrous.

Dangerous wind layers are most frequent at flying levels during the transition of fair to foul weather.

2. *Wind Billows.*—Wind waves analogous to water waves are set up at the interface between two layers that are moving with different velocities. If both layers are moving in the same direction the resulting waves are long and regular; if in different directions they are short and choppy. Therefore, other things being equal, it obviously is advisable to keep within the lower layer, or at least to get away from the billowy interface, either above or below, and to avoid crossing it oftener than is absolutely necessary.

3. *Wind Eddies (Central Portion).*—Eddies or horizontal rolls in the atmosphere are found on both the windward and lee sides, especially the latter, of cliffs and steep hills and mountains. When the

wind is strong a landing should not be attempted in any such place. If forced to land in a place of this kind the machine should be headed along and not at right angles to the direction of the hill.

4. *Aerial Torrents.*—Steep barren valleys, especially of clear still nights and when the upper reaches are snow covered, are the beds of aerial drainage rivers that at times amount to veritable torrents. Therefore however quiet the upper atmosphere and however smooth its sailing, it would be extremely dangerous to attempt to land an aeroplane at such a place and such a time.

Note

All the above sources of danger, whether near the surface like the breakers, the torrents and the eddies, or well up like the billows and the wind sheets, are less and less effective as the speed of the aeroplane is increased. But this does not mean that the swiftest machine necessarily is the safest; there are numerous other factors to be considered and the problem of minimum danger, or maximum safety, if the aeronaut insists, can only be solved by a proper combination of theory and practise, of sound reasoning and intelligent experimentation.

THE PHYSIOLOGICAL BASIS OF ESTHETICS

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IN its very etymology the word esthetics denotes perception of sense impressions and implies a physiological reaction between a sense organ and objective stimuli. The significance of the term has become modified to indicate rather the *feelings* produced by the sense perceptions than the mental picture itself. Certain of such are *pleasing* in their effect and the mind inevitably occupies itself in analyzing the factors giving rise to pleasing impressions and attempts to recombine them in relations the results of which will be still more agreeable.

Reason irresistibly seeks to formulate laws which may be used to construct ideals, or concepts of perfect beauty, and we thus have the origin of the fine arts. By general consensus of opinion there is drawn a more or less well defined line of separation between those pleasurable emotions which do and those which do not involve the intellect. The latter are indispensable to the vegetative life, subserving especially the functions of procreation and nutrition.

The former we intuitively apprehend as higher in their nature, leading us to conceptions of perfection, to ideals which lift us above the sordid struggle of selfish existence.

The fundamental query as to the nature and conditions of beauty has engaged the minds of philosophers from the earliest times. Why is one object or group of sensations beautiful, another ugly, another indifferent? "Why we receive pleasure from some forms and colors and not from others," says Professor Ruskin, "is no more to be asked than why we like sugar and dislike wormwood."[1] From Socrates to Herbert Spencer abstract thinkers have devoted their best energies to elucidating the origin and conditions of the Ideals that make up the apotheosis of life.

It would add little to the conception unfolded in the present essay to review the voluminous literature of esthetics; indeed, such a task is far beyond the powers of the writer. A comprehensive synoptical survey of the subject is given by Sully.[2]

The first writer to have attempted to coordinate the development of esthetics with the evolution of physiologic function seems to have been Herbert Spencer.[3] Grant Allen sought to give physiologic basis to the

[1] Quoted by Grant Allen, *infra.*

[2] Article "Æsthetics," *Encycl. Britannica,* 9th Ed.

[3] "Psychology," 2d Ed.

whole esthetic field.[4] Parts of the work of Marshall are especially helpful.[5]

The various conceptions of beauty entertained by any man or race of men strictly conform to the grade of general culture of that individual or that race. Therefore we find the ideals of beauty among different peoples to vary directly with their grade of development in intellect and feeling. Each one of us can trace an evolution of his ideals corresponding with the phases of his mental development.

It would seem, therefore, that an absolute ideal of beauty, whether in morals, in form, in sound or in vision, is not to be found; that the tom-tom of the savage and the violin of the master of symphony are of equal excellence because each expresses most adequately the emotional activity of its respective player.

But psychology remained much like a tractless chaos until students bent themselves to the investigation of laws and functions of the nervous system; and the rich accessions contributed thereby to the knowledge of the mind gives reasonable hope that perception of the beautiful may find in the sense apparatus, which is in general its physical basis, an orderly explanation of facts which otherwise seem without law. If it can be shown that certain esthetic states are dependent for their development upon the specific structure and mode of action of the body in its reaction to external stimuli, it is evidence that the resulting conceptions of beauty are not ephemeral but are founded on the laws of nature which do not operate by chance.

The proof that all esthetic pleasure depends upon a certain harmony between objective stimuli and the structure and operation of the sense apparatus would demand a number of concrete demonstrations correlative with the ideas of beauty.

Nevertheless our main thesis may be firmly founded on a single group of facts if it can be shown that the esthetic attributes of a sense organ arise out of an anatomical or physiological peculiarity of the apparatus which is not concerned in or is even opposed to its prime utilitarian function. Our knowledge of biology appears to be too meager to support a generalization in this field, but certain known facts as to the reactions of the visual apparatus establish that certain of its idiosyncrasies which would condemn it as an optical instrument lend themselves to the development of ideals of visual beauty.

The astonishing revelation appears that when in the evolution of our visual organs under operation of the Law of Usefulness the structure has taken on characters which are inherently subversive of its utilitarian functions, nature has, as it were, circumvented the tendency of these defects; and out of them arise interpretations of the external

[4] "Physiological Æsthetics," 1877.

[5] "Pain, Pleasure and Æsthetics," 1894.

world which lose nothing in exactness but gain something altogether new—esthetic feeling.

Vision is the sense which provides the mind with an overwhelming preponderance of the sensations which lie at the basis of esthetic conceptions. If it can be demonstrated that esthetic visual ideas are founded upon reactions which are dependent upon anatomical peculiarities of the sense organ, the main purpose of this argument will have been accomplished. The evidence follows:

The globe of the eye is admittedly the analogue of a photographic camera, but it is marked by mechanical imperfections that would completely unfit it for the projection of a sharp image upon the sensitive plate. For the eye lets in light not only through the pupil, which corresponds with the aperture in the photographic diaphragm, but the side-wall of the globe—the sclerotic coat and its underlying choroid coat—are penetrable to the light. Consequently, the whole retina must be bathed in a dim light which has entered through the wall of the eyeball. This light is diffuse, and since it has traversed many blood streams it must have acquired a reddish color.[6]

Under ordinary conditions of vision then, there is thrown upon the center of the retina a more or less sharply defined image of objects the light from which has entered the pupil. In addition, the whole of the retina is illuminated by a diffuse reddish glow, due to light leaking through the white of the eye, a condition the parallel of which would completely subvert the efficiency of an artificial camera. Apparently, then, evolution has produced for us an optical instrument which is hopelessly defective. But the sensitive film of the eye is alive and the impressions formed on it are interpreted through the aid of living structures. It is conceivable that what seem to be mechanical deficiencies in the eye may be compensated or even turned into actual benefits through physiological agency.

It is a familiar law of chromatics that whenever an objective color falls upon the retina, the affected area becomes fatigued for that color and refreshed for its complementary. The complementary color of red is green. Under the conditions named, then, the irritability of the retina for green is continually maintained through the influence of light leaking through the sclerotic coat. So long as this side light penetrates the globe of the eye, and such is the habitual condition in daylight, the perception for green is automatically refreshed and this color, therefore, excels all its companions of the spectrum in its ability to play upon the sensorium without inducing fatigue.

Now the characteristic tint of vegetation is green. A tree clothed with verdure never wearies the color sense. But look at this same tree through an opaque mask having eye-holes admitting light only

[6] Cf. Brücke, *Pogg. Annalen*, Bd. LXXXIV., S. 418.

through the pupils, and very soon the foliage takes on a rusty hue, the esthetic charm of the creation departs and the onlooker feels a sense of depression: all because the sidelight entering the white of the eye has been cut off.[7] Such may be the physical basis of that droop in spirits which every one is apt to feel on a summer's day when a cloud suddenly obscures the sun.

Such is one indication that the universal esthetic joy of the open, as far as dependent on the color sense, is specifically subserved by the physiological reactions of the eye, reactions which would seem to impair the efficiency of the organ as a mere optical apparatus. A mechanical defect is translated by physiological intervention into a psychic triumph.

In the foregoing it has been shown that esthetic feelings may be founded directly upon anatomical and physiological peculiarities of the eye. Now I will proceed in the converse manner and attempt to account for some intuitively perceived esthetic qualities by reference to idiosyncrasies of the visual instrument. It is doubtful whether ideals of beauty can ever be embodied by the conscious mathematical synthesis of their elements as a mechanic constructs a building by laying stone on stone.

I imagine that the creation of the artist at first appears to him as an intuition, of a quality determined by his race culture. and that he uses his techniuqe to put together objective materials to represent it. But such a work is its own justification; it is accepted and graded at its face value by a general consensus of cultured opinion, according as it is fit and pleasing, irrespective of the laws of physics and physiology. If it is beautiful it may claim place as a model of taste, needing no defense. Now if beauty of whatever sort is but the outcome of certain correlations of physiological and anatomical characters, it should be possible to point out the biological substratum on which depends the excellence of any work of art.

But few works of art appeal to all men as approaching objective perfection. Possibly one such structure in architecture is represented by a ruin—the Parthenon at Athens. Many themes have been written in admiring description of this building; much has been debated the secret of its charm. With great diffidence I venture to dwell upon certain reported peculiarities of construction of the Parthenon as they appear to me related to known facts of binocular vision, and to suggest that from this interdependence springs at least part of the esthetic satisfaction aroused by the structure.

Competent observers describe one physical detail in the construction of the Parthenon which has aroused much curious comment.

[7] Sewall, "On the Physiological Effects of Light which Enters the Eye through the Sclerotic Coat," *Journ. of Physiology*, 1883, V., p. 132.

No line and no form in the composition of the temple are exactly what they appear to be: . . . No horizontal line is really horizontal, and no vertical line really vertical, . . . every huge and massive feature is changed and almost imperceptibly deflected from the appearance it bears.[8]

The free edges, namely, of the edifice instead of being straight, as in a modern architectural design, are all curved gently in the arcs of large circles. The edges and vertical faces of the steps leading to the portico thus have a gentle convexity outward. The surface of the platform itself has the form of a very flat vault. The columns do not stand exactly vertical, but slant inward and their outlines are curved so that their actual thickness is greatest about one third the distance from the base. So great is the radius of curvature that to the casual glance there is no departure from straightness in the outlines.

Such being the objective mechanical facts, let us see what relation they may have to the visual physiology of the onlooker.

The physiological conditions may be made clear by means of a simple experiment. Let a cross formed of two strips of colored paper which intersect at right angles be fastened against a neutral tinted wall at the level of the eyes of the observer who stands at a distance of, say, ten feet. The gaze is fixed intently for some seconds upon the center of the cross. The image of the latter is thus impressed upon the retina, so that when the glance is directed elsewhere upon the wall a "negative after-image" of the cross is projected with startling distinctness upon the surface. When the eyes move so that the optic axes run along either the horizontal or vertical lines extending from the center of the cross the limbs of the latter maintain their true directions in the after-image. But when the optic axes are directed obliquely upward or downward, the cross seems to be inclined upon the wall, the vertical limb leaning at a greater angle than the horizontal. When the orbital movement is upward and to the right, the vertical part of the cross inclines to the right, it may be as much as fifteen degrees; the horizontal limb inclines downward to the right as much as five degrees.[9] When the oblique movement of the optic axes is upward to the left the inclination of the cross is to the left. Oblique downward movements give complementary results. The amount of angular inclination of the after-image is proportional to the range of oblique movement. The physiological explanation of this phenomenon is not here important; the results are such as would occur if the eyeball in its oblique motions rotated slightly like a wheel about its visual axis.

As an observer stands before an architectural structure, his gaze roving over its lines and surfaces, the extremely complex nerve-muscle

[8] "Greek Art and Modern Craftsmanship," *Edinburgh Review*, October, 1906, Vol. 204, p. 430.

[9] Le Conte, "Sight," p. 164. Internat. Scientific Series, 1881.

mechanism of ocular fixation must carry out its movements with an ease or effort determined by the external configuration brought into attention. It has been shown that in oblique movements of the eyes there is a definite rotatory movement of the globes, so that in following any line departing obliquely from the prime axis of vision it seems obvious that the fixation mechanism would suffer less fatigue when this line is curved objectively to correspond with the normal rotation round the visual axis. In following oblique lines which are objectively straight the fixation mechanism must be continually harrassed by the voluntary effort to maintain the contemplated line in the horopter.

No homily is needed to convince the modern physician of the paramount psychological importance of the motor sensations arising from the coordinations of the external eye muscles. As sensory disasters from eyestrain often result in muscular unbalance, it is not difficult to believe, conversely, that peculiar advantages may spring from unobtrusive objective aids to the action of the intricate machinery of fixation whereby the eye is enabled to rove over a picture without conscious effort. According to this view, then, the curved lines of the Parthenon are psychologically straight to the onlooker in so far as they parallel the normal inclination of the after-image in oblique vision. It is easy to believe that the physiological result of such relations is rest, absence of fatigue. But kind nature repays subconscious physiological coordination in a rich and peculiar way; the thing so seen and understood without effort arouses a new class of ideas—an esthetic feeling—beauty.

It may be objected to the foregoing argument that, though the outline of one side of a column may by reason of its curve allow the eye to glance along it without the effort of fixation, that of the opposite side, forming a reciprocal arc, must simultaneously offer an equally exaggerated impediment to ease of vision. I answer that the percipient mind tends to neglect all sensory impressions which interfere with the homogeneity of a mental picture. The infinite details of a landscape impressed upon the outskirts of the retinæ give rise for the most part to mental double images, but these in no wise disturb the acuteness of vision for an object projected on the retinal foveæ. Moreover, it is not intended here to imply that the idea elaborated above contains the whole physiologic basis of the esthetic charm of the Parthenon. Indeed, the author of the admirable paper[10] which has been quoted, whose thesis, by the way, ascribes the preeminence of Greek art to its foundation on physiological principles, himself gives other interpretations to the psychic impression produced by the temple. These explanations, however, do not displace, but rather complement that detailed above.

In the foregoing discussion evidence has been offered along two

[10] *Edinburgh Review, loc. cit.*

different lines that structural or functional properties of the eye which, considered from the purely physical point of view, would seem to impair the efficiency of the organ as a registrar and transmitter of objective visual facts, not only do not confuse the recipient sensory nerve centers, but, on the contrary, the psychical apprehension of objective phenomena is distinctly modified by the reaction to such instrumental defects in a manner which leads to the generation in consciousness of a state or an atmosphere of feeling—esthetic feeling. It is as if the stone rejected of the builders were made the chief of the corner.

In pursuance of this line of thought I will offer one additional illustration of the direct dependence of psychic perception upon what may be termed the structural aberration of the visual apparatus.

When external objects are viewed with one eye, held at rest, the image upon the retina is exactly similar to that upon the sensitive plate of the camera, it has length and breadth, but no depth, and it has no power of directly arousing in the mind a perception of the third dimension—projection.

It is inconceivable, indeed, that an anatomical apparatus should be capable of directly presenting to its sensory center an impression of depth. Such a perception is of purely psychological construction from simpler data derived from retinal impulses. By an exceedingly familiar line of evidence it can be shown that the direct visual perception of depth is dependent upon idiosyncrasies of binocular vision. It is a physiological law that an object viewed by the two eyes appears to be single only when the images which it casts upon the retinas fall upon "corresponding points" of the two surfaces. It is obviously of paramount importance to the instrumental efficiency of the eyes that there should be a horopter in which objective and subjective facts must coincide. It is well known that the fixation of objects by means of which their images are retained upon corresponding retinal areas invokes activity of most complex nerve-muscle machinery. Now when a small solid object is viewed with both eyes, it is clear that the right eye must see more of the right side of the object and the left eye more of the left side. Therefore it is certain that the images on the two retinas can not be identical and therefore can not exactly "correspond."

Some extra-mundane theorists summing up these facts would naturally reach the conclusion that distinct binocular vision is in its nature impossible. Nevertheless we know that the mental picture of external objects loses nothing essential in focal sharpness through binocular vision but, on the other hand, the two unlike retinal pictures combine, as it were, in the mind to form a new idea—the concept of depth.

Of all esthetic perceptions that of projection is the highest, the most purely psychic. Through it the universe is instantly converted from a

flat surface of two dimensions into an infinity reaching in all directions. If the unlikeness of the retinal images as seen simultaneously with the two eyes is really the physical basis of our visual perception of the third dimension of space it would naturally be suspected that the depth perception must become more lively the greater the unlikeness of the two images, up to a certain point. Manifestly the binocular images must depart from similarity in proportion as the eyes are further apart.

Pursuing this idea, Helmholtz contrived a most ingenious instrument the "telestereoscope," by which the distance between the eyes of an observer can be virtually increased to any extent. In its simplest original form the telestereoscope may be reproduced by joining at right angles the edges of two small squares of silvered glass which are then set into the middle of a strip of board having a length of, say, three feet. When the eyes are brought close to this rectangular mirror so that its edge is parallel with the bridge of the nose, it is evident that the right eye sees only the reflection of objects to the right of the field of view and the left eye those in the corresponding area on the left. At each free extremity of the board another, larger mirror is placed, so fastened by hinges that one mirror shall be movable round a vertical and the other round a horizontal axis. These terminal mirrors have their reflecting surfaces turned outwards, away from the observer.

In using the instrument the experimenter brings his eyes close to the fixed rectangular mirror so that they look into either reflecting surface. Now the terminal mirrors are focused on some distant object, as a tree, and it is easy to bring the reflections of the two images on "corresponding points" of the retinas and the distant object appears single but as if viewed by a pair of eyes separated by a distance of three feet. No one can realize, without having experienced its influence, the startling stereoscopic effect of such a view. For the first time in his experience the observer becomes enthralled with a perception of depth as a specific factor in objective impressions. It seems to the writer worth recording, as a suggestion in esthetic pedagogics, that after continued experimentation with this apparatus for some weeks, during which all manner of solid objects occupying the landscape was studied, there insensibly grew up in him an esthetic appreciation of depth, *per se,* which gave to all solid objects, viewed with the unaided eyes, a charm which immensely enhanced the pleasing combination of their natural attributes. The beauty in nature called more insistently from all her creatures. To sum up, in brief, the very dissimilarity of the retinal images which would seem to subvert the acuity of binocular vision is not only without disadvantage thereto but forms the physical substratum of a new psychic realm.

To the writer these facts and reflections seem very strong evidence that the principles of esthetics, like those of the psychology from which they spring, are fundamentally an outgrowth of physiological and anatomical factors and phenomena. The belief seems to prevail among psychologists that the general states of pleasure and pain are referable to functional nutritive metabolisms of the sensory apparatus which, on the one hand, tend to restore and, on the other, to destroy it.

There is experimental evidence that the emotion of fear and the sensations of pain, at least the sensations resulting from trauma, have a physical basis, manifested by histological alterations in the nerve cells of the brain.[11] It might be plausibly argued that the scheme of usefulness which is the basis of organic evolution accounts for the origin and development of an esthetic sense.

But the peculiar mechanical substratum of the esthetic faculty as far as it is related to the visual apparatus seems to be seated in *idiosyncrasies* of the sense organ which have, at first view, no important relation to its usefulness as a physical instrument; which, on the contrary, would seem to be impediments to the perfection of its main function. This is suggestive of the thought of Herbert Spencer that the distinguishing mark of esthetic sentiments is their separableness from life-serving functions.

Curious it is, and still stranger if a matter of chance, that where the utility of a sense organ ends its glory may begin.

[11] Geo. W. Crile, ''Phylogenetic Association in Relation to Certain Medical Problems,'' Ether Day address, Mass. Genl. Hosp., October 15, 1910.

ARE THE JEWS A "PURE RACE"?

By ABRAM LIPSKY, Ph.D.

NEW YORK CITY

DR. MAURICE FISHBERG has brought together in a book on "The Jews"[1] a great mass of valuable anthropological and sociological statistics. The work is likely to become a standard reference handbook for some time to come. For that reason it is deplorable that the author should have marred its value by over-zealousness in supporting a thesis that did not actually lie within the scope of his undertaking. He believes that the Jews are destined to be assimilated by the races among whom they live in Europe and America, and it is apparently in order to facilitate this manifest destiny that he arrays all the arguments he can muster tending to show that the Jews are not a pure race.

There are certain physical traits generally assumed by anthropologists to be distinctive of race. Dr. Fishberg finds that in these respects the Jews are not different from the races amongst whom they live. Certain other characteristics of a moral, social and vital or physiological nature, often ascribed to the Jews, are either denied existence or attributed by the author to economic and social status rather than to race.

The chief physical characteristics relied upon to distinguish races are stature, head-form and color. As to stature, Dr. Fishberg shows that the Jews rise and fall with the people in the land of their nativity, being short where the gentiles are short, and tall where they are tall, though never quite as tall. That stature is influenced by environment, is conceded by Dr. Fishberg—his own measurements on Jews in New York and those of Dr. Jacobs on the Jews in London leave no doubt on this point. A little of the Jewish variability in stature is reserved, nevertheless, to be ascribed to racial intermixture.

As to head-form Dr. Fishberg is more decided. The heads of European, Caucasian, African and Arabian Jews vary in shape. Some are long, some are broad, some are round. Only the commingling of the blood of different races could have produced these differences, argues the author.

Now, strange to say, in eastern Europe—in Russia, Poland, Hungary, Roumania—the Jews have remarkably uniform heads. These Jews

[1] "The Jews, a Study in Race and Environment," by Maurice Fishberg, M.D., Contemporary Science Series, Charles Scribner's Sons, New York, 1911.

constitute eighty per cent. of all the Jews in the world. Does this uniformity indicate unity of race? Not at all, according to Dr. Fishberg. The gentiles in these regions, who, we know, are of different races, also have remarkably uniform heads. It follows that the Jews acquired their uniformity of head-shape by fusion with their non-Jewish neighbors. That is to say: When Jewish heads are various in shape, it proves that the blood of various races flows in their veins, and when their heads do not vary much in shape, the same thing is proved. On one page Dr. Fishberg writes as if head-form were an unchangeable racial characteristic—on that page, since the heads of Jews in Europe, Africa, and Asia vary—the Jews are not a race. On another page, the Jews are not a race for the opposite reason, namely, because eighty per cent. of them have heads of the same shape—since it happens that the many gentile races living in the same part of the world also have similar heads!

Dr. Fishberg introduces his table showing how much alike are the heads of the Jews in eastern Europe with a remark from Professor Ripley's "Races of Europe." "The perfect monotony and uniformity of environment of the Russian people," says Ripley, "is most clearly expressed anthropologically in their head-form." If the environment is clearly expressed in the head-form of the gentiles, why is it not also expressed in the head-form of the Jews? The Jews have lived in that environment for the last ten centuries, at least. Would Dr. Fishberg suggest that Jewish heads alone are impervious to environmental influence? That environment has an effect upon head-form has been confirmed by the recently published measurements of Professor Boas on 30,000 immigrants and their descendants. These measurements show that, "The head-form undergoes far-reaching changes due to the transfer of the races of Europe to American soil. The east European Hebrew, who has a very round head, becomes more long-headed; the south Italian, who in Italy has an exceedingly long head, becomes more short-headed; so that both approach a uniform type in this country so far as roundness of the head is concerned . . . we are compelled to conclude that when these features of the body change, the whole bodily and mental make-up of the immigrants may change." Environment, it thus appears, may act directly upon Jewish heads as well as upon Russian or Italian.

Head-form has been regarded by anthropologists as the most stable of racial characteristics. If that, together with "the whole bodily and mental make-up of immigrants, may change," one need hardly be surprised to find that color of eye and hair too are modifiable by environment. Dr. Fishberg does not, however, allow such a possibility to disturb the serene course of his argument. You may mix colors by intermarriage of races, but nothing else can affect their everlasting fixedness.

The usual assumption is that the Jews, originally, if they were anything, were brunettes. But Dr. Fishberg finds that hardly more than half—52 per cent. of the males, and 57 per cent. of the females—are dark. The blonds, he concludes, must be due to past intermarriages with non-Jewish races.

Is the conclusion inevitable? Animals are known to change color with a change of environment—why not men? Professor Ridgeway in his presidential address to the Royal Anthropological Institute, January, 1910, refers to a bit of positive evidence that they may. Mr. J. V. Hodgson, biologist of the Scott Antarctic Expedition, reported that as a result of living under such unusual conditions, the eyes of the members of the expedition became so blue as to occasion remark on their return to New Zealand and also on their arrival home in England. "Color, therefore, like the cephalic index and stature, is also prone to change and in itself is not deserving of implicit trust."

Dr. Fishberg dilates upon the statistics of intermarriage between Jews and Christians in Europe to support his thesis that assimilation is the destiny of the Jews, as mixture has been their history. The figures for certain localities are sufficiently striking. In Prussia, during 1900–1907, there were 21 mixed to every 100 pure marriages. In Berlin there were. in 1905–6, 44 mixed marriages to every 100 pure Jewish marriages. In Hamburg and Copenhagen similar high rates of intermarriage are found. Dr. Fishberg argues that the Jews are bound to become even more composite as a race than they are now.

His zeal, however, seems to get the better of him. He points out that this intermarrying tendency means an appreciable loss to Judaism, and the more so since the children of mixed marriages tend to marry with Christians rather than with Jews. The children of mixed marriages are mostly brought up in the religion of the non-Jewish parent. "It is Ruppin's opinion that hardly ten per cent. of the children resulting from mixed marriages remain Jews for any considerable length of time. Of these it is doubtful whether any Jews are left after two or three generations." But a couple of pages farther on we are impressively reminded of the "new anthropological types" that are being introduced "among the children of Israel." We ask: If none of the offspring of mixed marriages are left among the Jews after two or three generations how can new anthropological types arise among them? And we ask further, whether the anthropological types that Dr. Fishberg finds now among the Jews arose in the same way!

He quotes Professor Boas's statement that if two types of equal number intermingle, there will be in the fourth generation less than one person in ten thousand of pure blood; and if one group is smaller than the other, it will, of course, lose its identity even more quickly. But Professor Boas assumes, in order to be able to make his calculation, that

the intermingling proceeds by chance, that there are neither artificial accelerations nor restrictions. Admit, however, that the mingling does not go on by chance, that there is a much more powerful tendency for kind to mate with kind than for intermarriage, and admit, further, that all the children of mixed marriages are drained off into one of the groups, leaving after the second or third generation none in the other, and you have a totally different result. Your smaller group, from which the offspring of intermarriage are drained off into the larger, will remain pure for ages, and a more interesting problem than of the purity of the smaller group arises, viz., the extent to which its constant losses have leavened the larger group.

It has been suggested by Professor Ripley that the Jewish type, if not due to racial continuity, may be due to choice, or, in other words, to sexual selection. Others have pointed out that in the principle of sexual selection we have an explanation for the resemblance between the Jews and the gentiles in every country where they live together. The gentile type being the dominant one, it becomes a distinction and a social advantage for a Jew to be of the gentile type. The gentile type of manhood and of beauty, commonly bolder, freer and happier than the Jewish, excites the admiration and envy of the victims of oppression. Hence, the gentile features are prized, selected and preserved. Dr. Fishberg agrees with Professor Ripley as to the effectiveness of sexual selection, but he denies that the gentile type would be the one selected. He contends that the Ghetto Jew abhors the gentile type. On this point we have only his own unsupported opinion. When it suits his purpose, Dr. Fishberg sees nothing but the Ghetto. He seems to forget the very considerable periods of comparative freedom the Jews have enjoyed in Europe. And what becomes of his thesis at this point? How could the intermarriages that he is so sure have taken place if there had always existed an abhorrence for the gentile type?

Dr. Fishberg finds nothing racially distinctive in any of the commonly alleged vital, social or moral characteristics of the Jews. Their great "tenacity of life" has often been spoken of. Statistics from the United States Census confirm the opinion as to their lower mortality. In the census for 1900 it is shown that their death rate is astonishingly below that of other people living under the same conditions. In three of the most crowded wards of New York city the mortality of the Jews was 17 per thousand; whereas the mortality of the Germans living under the same conditions was 22, of the Irish 36, and of the native Americans 45. Dr. Fishberg remarks upon this phenomenon that what we have here is not a racial characteristic. The low death rate of the Jews is not due to "tenacity of life"; in fact, adult Jews die as soon as other adults. The figures of the census merely indicate the fact of a low infant mortality, and this is due not to any racial peculiarity but to the

great care and watchfulness of Jewish mothers. There he leaves the matter. One naturally inquires why the Jewish mothers in those congested wards display a solicitude for their babes so much greater than other mothers in the same district, that half as many Jewish infants die as Irish, and two and a half times as many children of native Americans die as of Jewish! It will not do to say, as Dr. Fishberg does in one place, that fewer Jewish mothers work away from home. That is only putting the same fact in another way. Why do they not go away from home? They are just as poor as the Germans, Irish and native Americans in those wards. If a phenomenon of this sort were observed, say, among birds—such a greater affectionateness on the part of one set of mother-birds than on the part of another set, with such an astonishing difference in infant mortality—the ornithologist would unquestionably be strongly inclined to think he was dealing with different species of birds. Dr. Fishberg is studying types of humanity, whose evolution and differentiation are more along mental, moral and social lines than along physical lines; but when he comes to a phenomenon that is of a spiritual character he passes it by as a matter of small significance.

One would think that since Dr. Fishberg is so averse to attributing any of the observed peculiarities of the Jews to race, he would look for their causes in moral and religious habits that are distinctively Jewish; for if the Jews are not a race in the physical sense, they must be a religious community. But Dr. Fishberg's aversion to doing the one thing seems to be as great as his aversion to doing the other. He admits, for example, that the Jews all over the world show a remarkable freedom from alcoholism. "Many physicians state that in their professional experience they have never treated one for inebriety." Drunkards are rare among them. To what is this sobriety due? Neither to race, nor to religious or moral training, according to Dr. Fishberg, but simply to their life in Ghettos, which cut them off from the ways of the gentiles and gave them an abhorrence for their customs. The proof is that as soon as they emerge from the Ghettos inebriety increases among them. Here again we have only the author's unsupported statement as to a matter of fact.

The Jews are credited with immunity from certain diseases and greater susceptibility to others. Dr. Fishberg admits their surprising immunity from tuberculosis. Even when living in the most crowded and unsanitary quarters, their mortality from this disease is far below that of other people. What is the cause of this comparative immunity? Some say it is race; others, that it is their dietary scrupulousness. It is neither, says Dr. Fishberg. Their immunity is partly due to their freedom from alcoholism; partly to their long experience in urban life which has cut off those too weak to withstand the disease, leaving only

the comparatively immune. That dietary scrupulousness has had nothing to do with lowering the mortality from tuberculosis, argues Dr. Fishberg, is proved by the fact that the Jews in Harlem, who have become more indifferent to dietary regulations, are less susceptible to the disease than the Jews on the East Side. Here we have a very palpable example of Dr. Fishberg's special pleading and his effort to support his thesis even at the expense of consistency. If it be true, as he says, that Jews become more addicted to alcoholism as they emerge from the Ghetto, and if alcoholism is one of the chief causes of susceptibility to tuberculosis, then why are not the Jews of Harlem, emancipated from the Ghetto and more alcoholic as they are, according to the author, more rather than less susceptible to tuberculosis than the Jews on the East Side?

When no other explanation than race, or habits governed by religious or moral ideas, occurs to him, Dr. Fishberg prefers to plead ignorance rather than admit the effectiveness of these causes. He grudgingly confirms, for example, the comparative immunity of Jews from cancer. The striking exemption of Jewish women, especially, from cancer of the uterus has been confirmed by many physicians and Dr. Fishberg also affirms it. As usual, race and diet have been offered as explanations. Dr. Fishberg refrains from presenting a counter explanation because of the meagerness of our knowledge of the nature of cancer, but dismisses without another word the explanations that have been suggested.

If ever one would be justified in looking to religious and moral peculiarities for causes, it would surely be when dealing with statistics of crime. The Jews, Dr. Fishberg argues, are not a racial unit. They are some sort of a unit, or Dr. Fishberg's book would be without a subject and without a title. Call them a religious community, then, although scattered over the whole world. It is hardly necessary to dwell upon the close relationship between Jewish religion and Jewish morals. The Ten Commandments, the preaching of the Prophets, the minute legislation of the Talmud, all are aimed at regulating conduct. Can we assume that the Jews have remained a religious community for so many centuries, bound together by loyalty to these moral maxims, incessantly rehearsing and teaching them, without an appreciable effect upon actual practise? Dr. Fishberg's position implies that we must make this assumption. The statistics of Jewish criminality in those countries where they have been kept are remarkable. In Hungary, for instance, in 1904, there was 10.5 times as much manslaughter, 9 times as much robbery, 7 times as much homicide, 6.3 times as much assault, 4.23 times as much arson, in proportion to their numbers by Christians as by Jews. Similar statistics are available from several other countries. On the other hand, more Jews than Christians were convicted of bankruptcy, duelling, usury, fraud, perjury and forgery.

Dr. Fishberg concludes that there is nothing racial, moral or religious about this phenomenon. It is all explained by the Ghetto and by the nature of the occupations in which the Jews are engaged. Their freedom from crimes of violence is due to their weakness and cowardice; their proneness to mercantile crimes is due to their rapacity in business. As they emerge from the Ghetto and become physically more robust, crimes of violence too increase among them. That the terrible struggle for existence in the restricted areas to which they are confined in Europe is the cause of much transgression against the laws of property is probable: but weakness and cowardice explain nothing. The weakest and most cowardly are often the most quarrelsome and the most cruel among themselves. Jackals fear the lion, but they have no fear of one another. Dr. Fishberg has written a book about the Jews, as a people who are not a race or a nation, in his opinion, but scattered communities unified by religion, yet their religion has had no effect upon their lives, and its only outcome has been the Ghettos that Christians have forced them to live in!

As one proceeds through the multitude of figures, assertions and arguments in Dr. Fishberg's book, one becomes doubtful as to what he is really driving at. It would seem, offhand, that he wished to convince us of the fact that the people now called Jews are not descendants of the same original stock. "Ethnologically," he says, "there are practically no differences between Jews and other Europeans. Both consist of conglomerations of various racial elements blended together in a manner that makes it impossible to disentangle the components, or even the predominant race out of the ethnic chaos." But if his aim was to prove this, what was the use of wasting so much zeal and labor? On page 135 we are told, "One thing is certain, however, the original stock of the Jews was not made up of a single and homogeneous race, as is supposed by some." And again on the same page we read that the Bible itself records inter-marriages between Jews and gentiles and "that some of these races were not of Semitic stock has been established recently by archeological research." Why was it necessary to produce more evidence; why worry about blonds and long heads and short heads, if the Jews never were Jews?

But why should we be concerned whether the Jews are, or ever were, a "pure race"? What is a pure race? Would Dr. Fishberg know one if he saw one? If there ever was a pure race how did it come into existence? Was it born pure, or did it issue pure from the Hand of God? "Religion," says Dr. Fishberg, "the Jewish as well as the Christian and Mohammedan, with the assistance of the state, artificially created the types of the Jew at the beginning of the nineteenth century. There is nothing unusual that an isolated community should evolve peculiar characters." Does Dr. Fishberg know any other way

than isolation by which races acquire peculiar characters? The Jews of remote antiquity seem to have had characters sufficiently peculiar to cause themselves to be known as Jews. How did they get those characters? Was any thing but isolation ever the cause of such peculiarities? How did the American Indians, the Anglo-Saxons, the Ethiopians get their peculiar characters? Does Dr. Fishberg imagine they inherited them in an uninterrupted line of descent from a primordial group or pair that had them since first there were men on earth?

It could easily be shown that there is as much diversity of religion among the modern Jews as of physical type. If we followed Dr. Fishberg's method we could prove that the Jews are neither a race nor a religious community. And yet what have historians been talking about when they have written about the Jews? To what have the Jews, if we may still use the term, been loyal all these centuries? And to what shall be ascribed that Hebraic influence of which writers as diverse as Matthew Arnold and Nietzsche speak with confident appreciation or reprobation?

Dr. Fishberg seems to think that in presenting evidence tending to show that the Jews are not a pure race, he has provided the most deadly possible reply against those who dream of reconstituting the Jews as a nation. If the Jews are not a race, if all their peculiarities vanish as soon as you change their economic status, then it is folly with such material to undertake any work of reconstruction. The Jews are an evanescent phenomenon, and we shall be wise if we gracefully acquiesce in their disappearance. As if men interested in the welfare of their kind ever troubled themselves about such metaphysical entities as Dr. Fishberg's "pure race"! His contention that the Jews are not a pure race has no point. It makes no difference whether they are or not, since the only so-called pure races are a few small groups like the Basques and the Esquimaux, which, through long isolation, have attained a high degree of homogeneity—at least to European eyes. "Pure races" are anthropological postulates, like the atoms of physicists, which serve a scientific purpose but never can be brought in to decide practical questions of politics or engineering. Dr. Fishberg tries to use the conception of a "pure race" in such an illegitimate manner. In his eagerness he falls repeatedly, as we have seen, into inconsistencies unbecoming, to say the least, in a scientific work. After a candid perusal of it, one has to declare in true Irish fashion that the arguments do not prove that the Jews are not a pure race, and even if they did, it would make no practical difference to any one or any thing.

IS A SCIENTIFIC EXPLANATION OF LIFE POSSIBLE?

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THE restoration of this question in recent times to a position of some apparent respectability among the biological problems of the day is a striking example, not only of the vitality of misconceptions, but also of the vanity of men. Of course, we do not know all about life, or anything else, and probably never shall, but the outcome of this confession bears no resemblance whatever to the hopeless figure of a future, discounted, and forever condemned to total silence. To refuse the men of to-morrow the chance to explain what they can, may produce in some minds a pleasing artistic, or even philosophic effect, but no one can cut short the road to truth, or travel thither on his own terms, for the conditions under which nature transports us are rigid, unfavorable, and as plain as the rules printed on a railroad ticket. Nor is the rate low, for she demands not only money and unlimited patience, but all of our fondest prejudices, and our most natural and ingrained faults as well, must be left at the station window, before we depart. Nature gives passage only to modest folk who do not pretend to know everything before they start, and who are ready to give up the past, and let bygones be bygones.

If I were to ask for a scientific explanation of rain, I should be told that at a given temperature and barometric pressure, the air dissolves a limited amount of water vapor which evaporates chiefly from the surface of the ocean, and rises in the sky. When cooled, as it often is at high levels, or by chilling winds, the vapor condenses, and if the cooling proceeds beyond a certain point, the minute spherules that make up the cloud, enlarge by fusion to droplets that fall. Some of the drops that leave the cloud are larger than others, and in falling overtake the smaller ones, as the giant drops gliding down a window-pane devour the pigmies in their path.

While the answer given is incomplete, it is nevertheless useful, and should serve my purposes, for by means of it I may decide whether or not to go on a picnic, or to plant a crop. Of course I might ask for more information on evaporation, and for further details concerning the condensation of evaporated substances and whether the end-products of these two processes are identical. I might also wish to know more about the fact that sometimes a substance rises from the ground and sometimes it falls, and furthermore, how it happens that in a vacuum small drops and large fall at the same rate, but, however many

questions I might ask, from the man of science I should receive answers which, though differing in richness of detail, in principal would be invariable.

What is this principle? No matter how much the physicist, the chemist and the meteorologist might add to the chain of events as outlined, it would never be other than a chain of events. Even at the present time it might be lengthened almost indefinitely, and although this might show how much we know, it would also show no less clearly that all our knowledge is of one sort, and that scientific explanations, however many or few links we may have in our chains, never amount to more than the enumeration of the conditions under which the events in nature take place. Under the proper conditions evaporation occurs; when the conditions are right a cloud is formed; and, under the proper circumstances, rain falls. This is the chain: in it one event is the outcome of certain conditions and on its shoulders stands the next event if other conditions no less important have been satisfied.

There is something very instructive about a series of this kind, for study, not only of the conditions under which rain falls, but of the conditions under which anything whatever happens in nature, shows conclusively that all the conditions are equal in importance. We ourselves are such poor democrats, however, and so accustomed to special privileges, so much more interested in some things than in others, so inured to our worship of the exceptional and the peculiar, that when we meet with a situation like this, the language of the street, the habit of a life-time, and the teaching of centuries all unfit us for the task of interpreting nature as she really is. Nature is democratic; that which is the condition of an event is neither more nor less than that event's condition, and when, as is always the case, a group of conditions is the basis of an event, that event is suspended, or another takes its place, unless the tiniest condition has cast its vote in the primaries.

It is the neglect of this truth that leads to many of the difficulties of science, for her most ardent votaries are often bent on bestowing special favors among conditions, and now and again knight them. But knighthood among conditions is as precarious an honor in science, as a seat in the house of lords, for sooner or later the bogus knight falls in joust, and another, himself soon to be vanquished, takes his place. It has happened many times in the history of science, one need but think of the changes in the treatment of disease that first one cause, then another then a third has been assigned the leading rôle in the drama of causation, but each of these in turn has had his vizor torn off, and has stood exposed as a condition which, masquerading under the armor of special privilege, for a time succeeded in imposing on the public as a real cause. Indeed, no one who has set out on the quest for causes in science, has ever returned with anything else than a knowledge of

conditions, for the fountain of action escapes them as the fountain of youth receded before the searching eyes of Ponce de Leon. Nevertheless, the treasures on the road of the deluded are no less valuable than those strewn on the pathway of the sane, if they will but pick them up, and all the wealth of our much boasted "causal" biology has been brought home by men who were not lucky enough to get what they were after, but wise enough to take what they could find.

Those who have parted with their entire wealth of prejudice in the matter of causation can safely begin to discuss the question whether scientific explanations, explanations by means of chains of events, can be legitimately applied to vital action, and furthermore whether such explanations are useful. At the outset, however, they meet with a grave difficulty, for at the present time no one knows exactly what it is that needs to be explained. Some tell us, life is motion; others call it a chemical-physical process; whereas some declare it synonymous with consciousness. Herbert Spencer, after cudgeling his brains for many years, arrived at a statement which seemed to him, as it has to many since then, the best possible. "Life," he says, "is the continuous adjustment between internal relations and external relations."

Unfortunately none of these definitions is really satisfactory. Who, on being told that life is the continuous adjustment between internal and external relations, can feel that now he has the secret firmly in his grasp? Indeed at present a hard and fast definition is scarcely possible, and, if it were, would add more to the comfort of the dialectician than to the progress of knowledge. When we understand life the definition will come of itself, and then no one will care to use it.

Most of the biological work of to-day is an attempt to find out exactly how living things make their living, and the biologist, regardless of his party affiliations, is happy to say that all who study these questions agree that living things make use of machinery. Is not the respiratory system a machine by which oxygen is taken from the air and carbon dioxid given off to it? Is not the digestive system a factory which changes food-materials into simpler compounds that are absorbed?

The machinery of living things is very remarkable, complex, and adequate. It may not always be wholly adequate, but certainly in general it is sufficiently so. Sometimes it can be improved by surgery, by the prescription of glasses, hearing trumpets, false-teeth and tonics, but on the whole it is adequate, it is fit. Indeed, fitness more or less pronounced, but fitness, nevertheless, is the leading characteristic of living machinery and its processes, and under shifting external conditions, distinguishes them clearly from things not alive. No man need take the time to adjust himself consciously when he deals with his fellowmen, with horses, dogs and with building materials. Our famil-

iarity with the striking peculiarities of these substances is such that we pass with the greatest readiness from one to the other, and treat them all in essentially suitable ways.

What do we know about things that are fit in an ever-changing environment? In the first place they are things which have had a long history, and though we are still wofully ignorant of the conditions under which this history has been worked out, we do feel reasonably certain that all life is of a common stock, and that we have as good reasons for speaking of the brotherhood of living things as we have for speaking of the brotherhood of men. We know with much greater detail that fit things assimilate food, that they excrete wastes and that they secrete substances useful to themselves. We know too that they grow, repair wounds, and often restore very complex lost parts; that by a marvelous process of development they reproduce their kind from spores, gemmules, buds and eggs; and finally, we suspect that many of them have minds in some way like our own. We know with certainty that we ourselves have sensations, feelings, emotions, knowledge and the power to communicate much of all this to others. Strangest of all, we have a fairly complete equipment of self-knowledge, and we spend much of our time in thinking and talking about our origin and our destiny.

The anatomist tells us that things which do all this are composed of many complicated parts visible to the naked eye; the histologist analyzes these parts or tissues microscopically, and finds that they are made up of unit masses, the cells, or of the products of cells. From the embryologist we learn in detail how each of the myriad cells of the body comes from preexisting ones, and how by tracing development back to its earliest stages, we finally reach the egg. Cytology carries the dismemberment a step farther by discovering, classifying and naming, not only the minuter parts of the cell, but its very granules. Biological chemistry tells us what substances are found in the protoplasm; chemistry what elements are present and their proportion; physics that these elements are molecular in structure, that each molecule is made up of smaller units, the atoms, and finally, the newest physics of all dissects the atoms and promises to show that these, instead of being simple, are in reality constellations of electrons. When we consider that a single protein molecule may contain perhaps 2,304 atoms, more or less, that the number of protein molecules in a cell is unknown, that there are millions of cells to the man, we realize that our bodies are fearfully and wonderfully made, and that if our ears were sensitized to only a fraction of the rush and bustle within each protein molecule we should be deafened as with the roar of a Bessemer furnace.

This analysis is far from complete, but thousands of men throughout the world are contributing, each the small share which he can,

toward the unraveling of the great puzzle. Those who know most are least hopeful that we shall ever know all, but many will subscribe to the statement that the resolution into electrons is the last station suspected at the present time on the road which we are travelling. It is an interesting question, therefore, to consider what we shall have accomplished when we have resolved man by analytical methods until we can name each one of the electrons of which this remarkable being may possibly be composed.

In the distant future some Super-Zeiss may possibly make a lens more powerful and strange than Aladdin's lamp. In its focus, a man, with electrons as large as coffee-beans, would be but the transparent ghost of his real self, and the rush and swirl of his elephantine heart and the monstrous hailstorms rushing in and out of the elastic cloud-like lungs would startle and confuse even the hardened physiologist of those days. Under the circumstances the self-control constantly employed by every good observer might easily leave him and his cries of astonishment would probably be answered by cataclysmic tossings among huge masses of the illuminated brain of the man who was told to keep still and pay no attention to the professor.

The knowledge implied in all this transcends the whole of human experience, but there is no man of science worthy the name, who would not welcome it, or who does not hope that some day we shall understand these things better than now. If we throw ourselves into the future when the sort of knowledge to be got with the Super-Zeiss Illuminating Magnifier shall have become common property, we can imagine even the men on the street possessed, not only of astronomical acquaintance with living bodies, but also with the world in which these bodies live. These super-men may know that certain changes in the movement of the surrounding electrons are invariably followed by certain movements of the electrons in the brains and hearts of their fellow-men; they may know exactly what torrents and back-eddies of corpuscles occur when two friends who have not seen one another in twenty years meet on the pavement, and they may be able to describe in much detail the wild turmoil in the nervous system of the lunatic. But they will not be able to see the joy which friends experience on meeting nor the delusions of the insane. We may confidently expect them to have their own joys, sorrows, and imaginings, and that they may know what the physical concomitants of pleasure and pain in others are, but no feeling or thought will be theirs except their own. In this respect they shall be no wiser than we are, for we too can tell pleasure and pain when we meet them, but whereas we recognize them by smiles, laughter, lined faces and tears, the men of to-morrow may know these things by the movements among electrons.

Although physical analysis of men can never give us more than the

physical symbols of their consciousness, it would be the height of folly to consider this information complete, for it leaves out the most important thing about men. This greatest asset of all so transcends in value to us the knowledge of its physical basis, that even if every feeling and thought we have comes only with such changes in our brains as a skilful chemist and physicist might detect, measure and tabulate, it still remains true that we have used and are using our minds advantageously in the almost complete absence of such records. Had Shakespeare been dependent on a knowledge of the chemical changes in his nervous tissues as he wrote Hamlet, it is needless to insist that the play would not yet be written. To know a thing, to perceive and appreciate beauty, to recognize natural law and truth, all these are experiences in consciousness whose value and importance in human life no man can deny, nor can any man give a satisfactory explanation of the actions of his fellow-men without considering their feelings, emotions, and thoughts.

Since consciousness must be reckoned with in a scientific explanation of men, the question arises whether something analogous is not also true of living things in general. Does not the fitness of living things, the fact that they perform acts useful to themselves in an environment which is constantly shifting, and often very harsh; the fact that in general everything during development, during digestion, during any one of the complicated chains of processes which we find happens at the right time, in the right place, and to the proper extent, does not all this force us to believe that there is involved something more than mere chemistry and physics? Does not all this show that there must be present something, not consciousness necessarily, but yet its analogue —a vital X?

If we begin with what each one knows best of all, we may say that we can not doubt the existence of consciousness in ourselves. By intimate association with our fellow-men, and by comparing their acts with our own, we infer that they too are conscious, though we do not know this with the same certainty with which we know it of ourselves. If we descend in the scale of life, we know that it is practical to deal with many animals as though we knew for certain what in all probability is true, namely, that they also are conscious, but when we descend still farther, and reach forms built on a different plan, forms devoid of sense organs, and of brains, forms leading totally different lives, and with responses often simple and direct, what shall we say of them? Are they conscious? Is the amœba, the germinal disc of a hen's egg, or the sapling oak conscious? Nothing short of a method of communication as complete, delicate and trustworthy as the language of men, could ever enlighten us on this question, unless indeed we could transform ourselves at will into amœbæ, hen's eggs or oak trees. Even then we

might not know, for we might lose the organ of conscious memory on the way down to the beginning of things, a path up which, in a very real sense, every human being has come in person.

If the question whether living things are conscious can be answered positively in only one case, and with great probability for the rest of our fellow-men and some few of the higher animals, but not at all for the lower forms or the early stages in the development of the higher, practical needs force us to act on our ignorance, and to deal with these matters as they appear to be and not as they might be, although we cannot dogmatize and must grant the reasonableness of William Keith Brooks when he says: "As for myself, I try to treat all living things, plants as well as animals, as if they may have some small part of a sensitive life like my own, although I know nothing about the presence or absence of sense in most living things; and am no more prepared to make a negative than a positive statement." I do not know whom we should consider the greater fool, the man who went abroad declaiming about the unconsciousness of the oak, or him whom we should discover trying to teach an oak the Greek alphabet.

This is where we stand on the question of consciousness, but the question of the vital X is even more difficult, for we have no experience of it comparable to our first-hand knowledge of consciousness. I have not the faintest idea what living is like except as I know this consciously, for unconscious knowledge or experience is altogether outside my line of business. Hence if there is a vital X in ourselves other than consciousness, I know nothing about it, and if I can not even be sure of consciousness in most living things, I certainly can have no good reason for assigning to them an X of which I not only know nothing, but have no present means of knowledge.

The progress which scientific explanation has made in our own lives, however, should warn us that no one can tell what will come next. It is by no means inconceivable that some day we shall be so familiar with the physical-chemical changes which to-day we know as feelings and thoughts, that we shall be able to infer consciousness from these reactions with the same certainty with which we infer now that a match lit under the nose of a fellow-man has hurt him in much the same way as it would have hurt us.

To my way of looking at things, there are only two possibilities with respect to the vital X, and when the day comes on which the inference of consciousness from its physical symbols shall seem safe and just to the man of science, these possibilities will stand out even more sharply than they do in the present scientific dawn, for the man of the future, equipped with the knowledge with which we have endowed him, will be able to decide whether the X in question is a variety of extra-personal consciousness or a variety of nonsense.

So far as the second of these possibilities is concerned, the men of the future will be no better fitted to deal with it than we are, and as for the first it is practically like the other, and useless as an explanation for an explanation which by the nature of the case we can not understand, is a contradiction in terms.

Aside from the impotence of the vital X as an explanation, its spokesmen are guilty of reasoning unbecoming to men of science, for they attempt to furnish us with an efficient cause of vital action, a captain who steers the ship of life. But consciousness, the nearest known possible relative of the problematic X, is certainly not a cause in man's life, for however much prejudice may incline us to adhere to the opposite view, consciousness is neither more nor less than a condition. It is true that we must recognize it and deal frankly with it, for in its absence man's life assuredly would not be what it is. But the same thing might be said of respiration, of digestion, of the environment, or of any one of the multitude of conditions under which life occurs, and is what it is. And the same thing would unquestionably be true of the vital X, for if it could be proved to be something with which he who would give a scientific explanation of life must reckon, if indeed it were shown to be the element without which it is impossible to understand how the right thing happens in the right place, at the right time and to the proper degree, science instead of having engulfed a real cause, would simply be enriched by the capture of one more of the conditions under which some of the substances in nature live.

If nature were a limited system, there would be some hope of ultimate acquaintance with all the conditions of life, but as the universe is unlimited, no foundation for this hope exists, and one need but reflect, as Brooks did, on the growth of knowledge to realize the truth of these words:

Each scientific discovery shows us new and unsuspected wonders in nature. The unexplained things which are brought to our knowledge by each scientific explanation far outnumber the things it explains. The progress of knowledge is no mere comprehension, or gathering in. It is more like sowing seed than gathering a harvest, for the known world grows with knowing.

We are told that "when every fact, every past or present phenomenon of the universe, every phase of present and past life therein, has been examined, classified and coordinated with the rest, then the mission of science will be complete." But if we are to judge the future by the past, classification and coordination will always show us more unclassified and uncoordinated things than they classify and coordinate.

Each new encyclopedia is bigger than the one before, and so, no doubt, it will be to the end. If knowledge were nothing more than comprehension, or the analysis and classification of facts, the progress of science should be bringing us nearer to universal knowledge, but each new discovery puts it farther from our grasp than before, and they who know most, are most convinced of its

unattainableness, not because the reality of things is unknowable, but because of the innumerable multitude of things knowable.[2]

But even if nature were a limited system and we were able to get into possession of all the conditions under which any event within this system occurs, we should still be no better off, for the external conditions under which our imaginary system would be what it is, could never be known. The student of life, of chemistry, of physics and all others, would find their experience hedged in by an impenetrable wall, beyond which they could not go. In an unlimited world, however, there can be no theoretical limit to experience, and while at any time we are actually hedged in by our ignorance, this wall is fortunately capable of being moved by human powers, and the road to further exploration is clear for all who wish to go that way.

Since exhaustive knowledge in an unlimited universe is clearly unattainable by us, it follows that a scientific explanation is a growing explanation, and of necessity always incomplete. So far as it goes, we have a scientific explanation of life to-day, but it satisfies almost no one because the most important things remain unknown, and our explanations are inadequate to meet our practical let alone theoretical needs. These inadequacies have tempted many to fill out with art what they lack. in knowledge, but the deficiencies of science, coupled with the certainty that there is no limit in a limitless universe, to what we may find out, to the man who is true to the scientific standard, are the greatest stimuli, for there is no joy equal to that which comes from extending the bounds of knowledge, for even though she tells us nought of "lunar politics," nevertheless, "all the things thou canst desire are not to be compared unto her."

To many men the realization that the work of science is unending and that she can extend no hope of ultimate explanations, comes as a blow, but this is neither more nor less than the just reward of all who take the universe lightly. This particular limitation biological science shares with all her sisters, for her failure to give us anything else than the physical symbols of life is a shortcoming by no means peculiar to the application of scientific explanations to vital phenomena. The physicist might analyze hydrogen and oxygen with the same magical lens which we applied in imagination to man, and if present opinions are correct, he would see the constellation of electrons that constitute the hydrogen atom and the constellation that makes up the oxygen atom. If he were an experimental physicist, he might take an electron out of the hydrogen atom and replace it by one taken from the oxygen, and be surprised, or not, according to his preconceptions, that substitution makes no difference. Further analysis might tell him that the hydrogen

[2] Brooks, W. K., "Intellectual Conditions for the Science of Embryology," *Science*, Vol. XV., pp. 453–454.

constellation differs in the number and movement of its constituent electrons from the oxygen constellation, and that both constellations are differently related to the rest of the world, but why one set of relationships should be hydrogen and the other oxygen would be revealed to him as little as it will ever be revealed to the biologist why one kind of corpuscular movement in the brain means pleasure, whereas another means pain.

Unfortunately, the biologist has no more senses than any other man; all that he tries to do is to use those he has to the best of his ability. It so happens that the senses with which he learns, and the brain with which he reflects, have evolved from simpler conditions, but however different the early stages of these organs may have been, they were elements in the fitness of his progenitors, and he believes that his natural endowments, limited though they be, are no less serviceable to himself and his fellows now than they were in pre-historic days. To-day more than at any previous time in the history of civilization it is coming to be recognized that the results of the application of our senses to the study of nature are racially essential. Another and closely related truth, however, still has to fight hard for its daily bread, for it is unfortunately by no means generally known that scientific results are not, and can not be, got directly for the asking. Most men of his day, had they known about it, would have considered James Watt a fool, for instead of watching the steaming mouth of a tea-kettle, a thing which millions of men had seen before, and have seen since, and to no particular advantage either, he might have been occupied with the more obviously useful task of chopping wood for the fire; yet to these fire-side dreams we can trace the whole of modern travel by steam. Perhaps Gregor Mendel, in the opinion of those who saw him pottering over his peas, would have done better to devote more time still to the affairs of his extraordinarily well-run abbey, yet upon his careful, thoughtful and beautiful observations rests the modern science of heredity, and the hope for the betterment, not only of our plants and animals, but of our very selves. Perhaps the man who hunts for frog spawn in the early spring would be better occupied removing the ashes from his cellar, yet it was a man with just this vagary whose tadpoles not only enlightened him and all the world as to the manner in which nerve fibers grow, but the methods developed in the course of these studies are now being applied for the purpose of determining the conditions under which cancerous growths occur, and consequently are freighted with the possibility of both the prevention and cure of this terrible scourge of middle and old age.

This is the method by which scientific explanations and their application come about, and however much we may regret that knowledge does not grow more simply and directly, the reason for this lies in the

structure of nature herself. Nature is a great system of things wherein mediately or immediately everything is related to everything else, and the scientific problem is the discovery of these relations. That many of them are so remote that no man could have foreseen them, is not our fault.

It is this remoteness of natural relations that so frequently startles us when discovered, and it is likewise the remoteness of things that justifies every stroke of work on problems the solution of which no man can evaluate in gold or silver. Indeed our usual standards break down completely here, for the measure of science is not in money, but in happiness, and the market value of this is uncertain, since no man, consciously or at least voluntarily, places his own happiness on sale. To ask for the monetary equivalent of the scientific discovery that our bodies are derived from a single cell, is like asking for the price of a friend. Brooks, in a suggestive paper on universities, wrote:

> While the benefits which learning confers are its only claims to consideration, these benefits will cease as soon as they are made an end or aim. All men prize the fruit, but . . . the tree will soon be barren if they visit it only at the harvest; they must dig about it and nourish it, and cherish the flowers, and green leaves. The gifts of learning are like health which comes to him who does not seek it, but flies farther and farther from him who would lure it back by physic or indulgence.

If material benefits, however, had been the only products of scientific explanation in his day, Huxley, according to his own confession, would not have been cared greatly to toil in the service of science, but would have enjoyed equally well the less complicated activities connected with quietly chipping his flint ax after the manner of forebears a few thousand years back. He tells us:

> The growth of scientific explanation has not only conferred practical benefits on men, but in so doing has effected a revolution in their conception of the universe and of themselves, and has profoundly altered their modes of thinking and their views of right and wrong. I say that natural knowledge, seeking to satisfy natural wants has found the ideas which can alone still spiritual cravings. I say that natural knowledge in desiring to ascertain the laws of comfort, has been driven to discover those of conduct, and to lay the foundations of a new morality.

It is more important, infinitely more important, that I should know and understand the immediate as well as the remote consequences of any action of mine, than it is that I should travel in seventeen hours, in luxury, to New York, and scientific explanation enables me to do both.

It is because we are apt to be so much more impressed by a practical application than by the conditions under which such application is possible, so much more by prominence than by importance, so much more by the gun than by the man behind it, and lastly because science modestly acknowledges her limitations, that she has fallen into ill

repute in many quarters. But Cinderella, to paraphrase Huxley's apt characterization of science, modestly conscious of her ignorance in high matters, lights the fire, sweeps the house and provides the dinner, and in reward for this, is called a base creature, devoted to low and material interests. But this charge shows nothing so well as ignorance of her ways, for in her garret she has visions of the order which pervades the seeming disorder of the world, visions of the great drama of life, with its full share of pity, terror and also of abundant goodness and beauty. She has at her command, knowledge which she is ever ready to place at the service of those who will use it, and she knows enough about ethics to foretell social disorganization from immorality with the same assurance with which she predicts bodily diseases from physical trespasses. No brighter light than hers is set for mortals in all the firmament, and by its light, dim though it be at times, we must walk, devoutly thankful for the few rays of insight that now and again illumine the path.

SOME FEATURES OF THE ROOT-SYSTEMS OF THE DESERT PLANTS

By Dr. W. A. CANNON

DESERT LABORATORY

THE roots of the desert plants are of interest, in part because of their relation to the physiological activities of the shoot, and in part because of their own physiology. There is a close relation between the character of the roots of the desert plants and the distribution of the plants, and probably with many other activities of the plants, as, for example, the formation of the leaves, of the flowers and the taking on of new growth. What the precise relation may be between the root-systems and the adaptation of desert plants to desert surroundings is not known, nor, for that matter, the relation of the roots of the plants of the more humid regions to their distribution, or to their origin. Also the special relation of the roots of plants to the substratum has not been extensively investigated, as, for example, the character of root development as related to the precise per cent. of water content, or to the temperature. The lack of quantitative experimental studies on roots in soil is to be attributed in large part to the difficulty in studying the soils. If certain activities of the roots, or the significance of root character to many features of the plants' activities, are to be understood, it will be necessary to do quantitative experimental work on plants *growing in the soil,* and not, as heretofore extensively done, growing under highly artificial conditions.

It is popularly supposed that the roots of the desert plants are very long—that is, that they penetrate the ground to great depths, and from this that the length of a root-system is in some way a measure of the aridity of a locality. It is difficult to say how this idea arose, which really is without adequate foundation, because a relatively small amount of work has been done on the roots of the plants either of the humid regions or of the deserts, in the field. It is probable, however, that the few excavations that have been made have been carried on in those places where it chanced that the roots penetrated to great depth. But it is in exactly these places where the most favorable moisture conditions of the given locality are to be found, namely, where the soil is deep, giving an opportunity for the penetration of water to a great depth, as in the bottoms, or along the banks of stream ways—arroyas in our southwest, ouedes in southern Algeria, or weds in the eastern Sahara.

From this it is to be seen that the localities referred to, instead of being typically intense deserts, are, on the other hand, the most favorable situations as regards moisture.

It is difficult, at present, to state under what conditions the roots of the desert plants are formed, owing mainly to the lack of experimental evidence. But by a system of reasoning backwards from the mature root we can possibly picture to ourselves something of these conditions. In the first place, if we examine the root-systems of desert plants, in the field, during the season of drought, we shall find it very difficult, if not impossible, to find any portions which show vegetative activity, although it may be possible at the same time to demonstrate a certain, even if low, rate of transpiration. On the other hand, if the root-systems of the desert plants are examined during the rainy periods, there will be no difficulty whatever in finding fresh growth, new rootlets of whatever kind. But that this is not the whole story is evidenced by the fact that in winter many of the plants native to the southwest do not form new roots, or, at least, I have not been able to find new roots. In spite of this fact, such plants as the flat opuntias do, in winter, absorb water and very promptly after rains. This is shown by the thickening of the fleshy and flat stems. It is therefore probable that a certain amount of heat as well as of moisture is required to bring about the formation of fresh roots. In addition to these two factors, there is probably another one, namely, aeration of the soil. Whether this is mainly concerned with the formation of the roots or of the position occupied by the roots in the soil is not known. It seems highly probable in certain cases, particularly in fleshy plants like the cacti and some liliaceous forms, that the amount of air in the soil must be of importance in determining the position occupied by the roots. So far as observation goes, the roots formed may be classed in at least two categories: (1) They constitute the extension of the roots previously formed and (2) they may appear on much older roots, but are of limited growth. It is supposed that in the main the greatest amount of water taken into the plant comes through the roots of the first kind, so that the place of water absorption as the roots grow, ever becomes farther from the stem, and the problem of water transportation is ever an increasingly difficult one. This last one is probably to be considered a very important matter on the desert where the evaporation rate is often very high, caused by the low relative humidity, by high temperature and by air currents. It is conceivable that, given favorable conditions, a large proportion, possibly all, of the roots of this character might remain alive, but, as a matter of fact, in desert plants, as before noted, it is difficult during the dry seasons to find any living roots of this class. As one result of this we find that the extension of the root-systems as a whole, away from the central plant axis, goes on relatively slowly, and

probably most of the rootlets formed in any season perish before the close of the succeeding dry season.

As regards the second class of roots referred to, there is quite a different story to tell. These roots are apparently quite as deciduous as the leaves of many plants. It should be noted, however, that nothing has been done in an experimental way to test the longevity of these roots, and it is reasonable to suppose that under some favoring conditions they might endure, possibly becoming converted into large laterals, even if under conditions, which are the usual ones, their life is limited.

It may be well to describe the roots referred to. If we examine a root of such a desert shrub as *Franseria,* we shall find, along such of the roots as extend in a more or less horizontal direction from the stem of the plant, groups of filamentous rootlets. These occur at about 1 cm. intervals, in varying numbers usually about one half dozen together. They are from two to four cm. long and probably not more than one half millimeter in thickness. The rootlets appear promptly with the coming of the summer rains, and they cease their activity when the soil attains to an unbearably dry condition, as perhaps in adobe soil, 10 per cent. moisture, more or less.

The deciduous rootlets greatly increase the absorption surface without, at the same time, necessitating invasion of new root areas, or of causing a long transfer of water from the place of absorption to the stem. So far as is known, the deciduous rootlets are formed only when there is an abundance of water, and when the temperature is high. These rootlets have been seen on most of the desert shrubs, on all in the vicinity of the Desert Laboratory, and have been observed on a few of the shrubs in southern Algeria. Whether a similar kind of rootlets occurs on perennials in the more humid regions is not known to me.

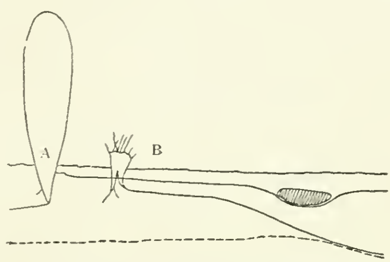
The deciduous rootlets are thus of great importance to such desert plants as bear them. They appear adventitiously always, and apparently in the same place on the root year after year. In certain species it has been observed that the adventitious roots are formed precociously, but in other forms this is not the case. And again, where such rootlets are not to be found, it appears that they can not be induced.

The extension of the roots of the desert shrubs is various, perhaps in no case exceeding three or four meters. The position in the ground is also not uniform. In most instances the position occupied by the roots is characteristic for the species, but it is likely that the extension of the root-systems varies mainly with the age of the individual.

There are three main types of root-systems to be found in the shrubs of the desert plants of the southwest. (1) Root-systems which extend horizontally from the main plant axis and lie, for their whole course, near the surface of the ground. (2) Root-systems which are characterized by a strongly developed tap root going directly down to a depth

determined in part by the character of the soil, in part by the penetration of the rains and in part by the character of the root itself. (3) And roots that not only reach widely, but also penetrate fairly deeply.

The superficial root-system (Type 1) is characteristic of many plants, particularly of the cacti. In some instances all of the roots except the anchoring roots, which, however, may not penetrate more than 50 cm., may not be more deeply placed than from 2 cm. to 5 cm. so that with a cane one can easily remove the root and then with little exertion can strip it from the soil to the base of the stem. Perhaps the root-system of *Opuntia arbuscula* (?) is the most superficial of any thus far described. In this species the ideal superficial root-system just alluded to finds complete expression. But the giant cactus also, although it is now reckoned among the trees, has a root-system which is essentially superficial. The accompanying figure gives a good idea of the position occupied in the ground by the root-system of a small giant cactus. The plant referred to was 1.2 meters high. The supporting system consisted of a stout root crown from which proceeded a few relatively slender branches, and the main absorption system consisted of long, slender branches and superficial roots which extended as far as three meters from the base of the plant. It may be said, in passing, however, that as the giant cactus becomes large, the anchoring system, sufficient in its younger stages, is no longer strong enough, and the bases of the superficial laterals increase greatly in thickness and form props by which the upright position of the cactus is maintained.



Giant cactus (*Carnegiea gigantea*), *A*, VERTICAL EXTENSION OF GIANT CACTUS. growing in association with a creosote bush (*Covillea tridentata*), *B*. The anchoring roots of the cactus and the superficially placed absorbing roots are shown in position. It will be seen that the roots of the creosote bush, which are of the generalized type, occupy a lower position in the soil than those of the cactus. Between the surface of the soil and the dotted horizontal line is the adobe soil, here about 30 cm. in thickness. Below the dotted line is the hardpan, caliche, which is impervious to water and is not penetrated by the roots.

There are several plants which illustrate the pronounced forms of the tap root, among which, in southwestern Algeria, may be cited the *Tamarix,* and certain other small shrubs, and in our own southwest such a form as palo christi, or Christ's thorn. *Zizyphus* also, which occurs both in southern Algeria and in the southwestern part of the United States, has a pronounced tap root. I will refer especially to the root-system of palo christi (*Koerberlinia spinosa*). The *Koerberlinia spinosa* is a close-growing, spinous shrub without leaves at any stage,

which grows in the bottoms, or along the sides of the bottoms, in the vicinity of Tucson. The young plants have roots which strike directly downward, giving off almost no laterals within one meter of the surface of the ground. The depth to which the tap root attains has not been determined. As the plant becomes older a sucker is sent out close to the surface, from which there springs up a daughter plant. Adventitious roots occur along the course of this sucker, particularly where the daughter shoot arises. Occasionally the connection between the daughter shoot and the mother plant is not destroyed, and the adventitious roots in that case are not very numerous nor very long. Sometimes, however, the connection between the plant and offspring is broken and the adventitious roots, or one of the adventitious roots, strike straight down and behave precisely as the main root of the parent plant. That is, in this case, as in the *Zizyphus* and *Tamarix,* the root-system is an *obligate* deeply penetrating one, for which reason the species is confined to such localities as provide sufficient depth of earth.

The third type of root-system, which may be called a generalized type, is such as is possessed by most of the plants growing in the vicinity of the Desert Laboratory, and in fact by most of the desert plants. Perhaps it would be clearer to state this in another way, namely, that the plants which cover the greatest area in the arid region are such as have the generalized type of root-system. It will only be necessary to refer to the root-system of the creosote bush of the southwest for an example of this type. The roots of the creosote bush extend outward from the main stem for a distance of about three meters, less in small plants, and reach downward, either directly or at an angle, to a depth which is usually determined by the character of the soil. On the mesa, where the soil is usually less than one half meter in depth, the roots of the creosote bush do not exceed that depth, but in the beds of the washes, or rather on the flood-plains of the washes, where the soil is deeper, they have been known to attain a depth of over two meters. From this it is seen that the generalized type of root-system is more flexible than either of the other two types given, and it follows, other conditions being equal, that species with the generalized type of roots may also have a wider local distribution.

It is interesting to note that the most arid portions of an arid country are the areas which are above the flood places of the washes. In the southwest these are usually the mesas. In southern Algeria, for instance, these excessively dry areas are the regs, or the hamadas. It is to lower-lying areas, washes and the flood-plains of the washes that drainage from the higher ground flows, and also where particles of soil from the higher ground are deposited through water or through wind action. And the result is that the low-lying areas have deeper soils and more water than the upland.

We therefore conclude from what has just been said that the most arid portions of such deserts as those in the southwest of the United States are on the higher lands, and the less arid portions in the lower lands—the flood-plains or the washes—and that it is only in the less arid areas that plants with pronounced tap roots occur.

It should be definitely pointed out that the foregoing classification of roots is applicable only to such deserts as that of the Tucson region, where a portion of the flora consists of plants with a water balance. In the more arid regions, such, for example, as southern Algeria, fleshy plants are almost entirely absent, and root-systems characteristic of such plants are consequently not to be found. We therefore have in the most intensely arid desert plants with two general types of root-systems only, namely, the generalized type and that form which has a well-developed tap root. In southern Algeria, for example, species of the genus *Haloxylon* have a modified generalized type of root-system, and this species occupies the plains—the reg or hamada—where the soil is least abundant and hence where the water relations are least favorable. In the hollows of the plains where soil has accumulated to some extent, and along the washes or oueds, we find plants with the main root especially well developed. In fact, it is only where the soil is actually or relatively deep that such forms as *Tamarix, Zizyphus* or other relatively large forms all having long deep roots, are to be found. From the character of the roots of plants from the plains of southern Algeria, as well as the roots of plants from southwestern United States it is to be seen, therefore, that if any type of root is entitled to be called the xerophytic type, it is the generalized form, and not the deeply penetrating tap-root form which is thus seen to be the peculiarity of plants which grow where conditions are relatively favorable.

Turning now to consider briefly the environment of the roots of desert plants, we should note, in the first place, that the root environment of these plants is not at all well understood. This, of course, comes partly from the fact, as before pointed out, that the soil is difficult to study. However, certain features of the soil, such as the water content, the temperature, and certain other features, which are best known, can be treated briefly.

As a general thing the rains of the desert do not penetrate the soil to any considerable depth. In the Tucson region, where the rainfall does not exceed 30 cm., the penetration of the ground is usually not over 50 cm., although this varies with the variation in the character of the soil. The water table usually lies so deep that the water is not available to the plants. On the mesa, in the vicinity of Tucson, for example, the water table is frequently 25 meters, or more, deep, but on the flood-plain of the Santa Cruz River, it varies from 3 to 10 meters. Under earlier conditions, which need not be described in this

place, it is probable that the water table on the flood-plain of the Santa Cruz River, nearer the surface than at present, was tapped by the roots of the larger plants, for instance, the mesquite, growing there. The depth to water in other desert regions, as for instance, southern Algeria, is very variable, but usually great. For example, at the daya of Tilrempt, on the northern edge of the Sahara, the water lies between 50 and 90 meters deep, while in the vicinity of Ouargla it is frequently no deeper than 1.5 to 2 meters. In the latter case, however, the water is highly charged with salts.

The length of time that the water in available amounts remains in the soils following storms is a variable one. In the vicinity of Tucson the soils of the river flood-plain, and of Tumamoc Hill, remain moist for a period exceeding six weeks, but the deeper levels are moist for a somewhat longer period. It has been stated that in the vicinity of Tucson, at a depth of about 20 cm., the soil is sufficiently moist to be of benefit to plants throughout the year. However, it should be said that if the activities of the perennials, or of the annuals, can be taken as indicators, the period of maximum activity, which should indicate the optimum water content of the soil, is not of long duration, perhaps not exceeding six weeks, which would include the rainy season.

A relatively small amount of work has been done on the temperature of desert soils. For a period of about five years there has been kept at the Desert Laboratory a continuous temperature record at two depths —15 cm. and 30 cm. But only a relatively few observations have been made at a depth of 2.5 cm. As a general result of the soil temperature studies it can be said that at the depth of 15 cm. the greatest diurnal range, which usually occurs in March and July, is 12° F. The extreme yearly range at this depth is 73° F. In January the temperature begins to rise, and rises gradually until the last of March, when the rate becomes accelerated, so that by the last of spring the soil approaches the temperature characteristic of summer. The highest temperatures occur in July just before the midsummer rains. When the rains come the temperature falls 5° or 10°. The minimum for the year is reached in December.

Soil temperatures at the 30 cm. level are very different from those just given above. In the first place, the daily range in temperature is usually not over 2°, and the maximum not above 4°. The minimum temperature at a depth of 30 cm. occurs in March. In the first part of April the soil begins to get warm and the temperature arises until the rains of midsummer. The fall in temperature of the soil occurs during seven months of the year and the rise in temperature of the soil at this depth occurs during five months of the year.

Unfortunately the temperatures for 2.5 cm. depth have not been taken throughout the year, but are available for spring months only.

So far, however, it would seem that the variations in the temperature of the soil at that depth are considerable. For example, one day in the spring the variation at the depth of 30 cm. was 3° F. At the depth of 15 cm. it was 11° F., while at the depth of 2.5 cm. it was 40° F. The greatest difference in maximum temperature at any moment was on April 15, when there was a difference of 23.5° F. between the upper two levels.

From what has been said regarding the soil temperatures it will appear at once that at any moment during the daytime the roots of the desert plants are subject to a very large temperature stress. Those roots which penetrate most deeply, where probably moisture is the greatest, are in the coldest soil, while such roots as lie near the surface of the soil, where the moisture conditions are least favorable, are in the warmest soil. We therefore have the interesting paradox that roots placed where there is the most water are not so advantageously placed, physiologically speaking, as those roots where there is least water, for the reason that low temperature retards absorption. This is probably of considerable importance to perennials whose root-systems live throughout the year, but its exact effect has not been studied.

While speaking of the temperature of the soil, it may be interesting to glance briefly at the effect on the development of the root-systems of desert annuals which is brought about by a variation in the relation of the temperatures of the soil and of the air. Briefly stated, the case is as follows: In the "Root Habits of Desert Plants"[1] the root-systems of the winter annuals are described as being easily distinguished from the root-systems of the summer annuals, because among other features the former have a more prominently developed tap root, and a poor development of laterals which are generally filamentous, or at least extremely slender. The summer annuals, on the other hand, have root-systems which resemble the generalized type, above described, of certain perennials; that is, the laterals are developed well, they are frequently rather coarse and the main root is often forked, thus the absorbing surface of the summer annuals is apparently greater than those of winter. The apparent reason for this difference is as follows: When the rains of summer come, the air temperatures fall disproportionately to the decrease in temperature of the soil, so that the soils are moist and relatively warm while the air is moist and relatively cool. In winter, on the other hand, the soils are always cooler than the air, which sometimes may be very warm. Under the first conditions the root absorption is favored, but under the latter conditions root absorption is not favored—conditions which lead to a strikingly different development in the two types of plants.

[1] W. A. Cannon, Publication No. 131, Carnegie Institution of Washington, 1911.

We can only consider briefly the root-air relation, since little work has been done on the soil atmosphere. We therefore do not know the rate of movement of air in the soil, or, for that matter, its composition. It is probable that there is a large per cent. of carbon dioxide where there are a relatively large number of roots of plants, but as to the diffusion of oxygen from the air into the soil or the diffusion of carbon dioxide from the soil into the air, little appears to be known. Preliminary tests show that there may be more movement of the air in the soil than might at first be supposed, and that varying, even if small, atmospheric pressure may directly affect air movements in the soil. For examples, if a tube 50 cm. long and 2 cm. in diameter be filled with soil composed of sifted sand and adobe—one part of the former to two parts of the latter—it will be found that a water pressure of only 1 cm., or less, will be required to force a continuous stream of air through it. The pressure given is for soil saturated with water. When air-dry, there is almost no resistance. In soils of this composition, therefore, it is probable that ordinary variation in atmospheric pressure is sufficent to induce in it rapid air movements. Preliminary experiments, in which a stream consisting of 20 c.c. of air a minute was passed through the soil where the roots were placed, indicated by the great vigor of the plant, and the relatively extensive root development, that that amount of air was beneficial to development and forwarded growth. Variations in temperature with depth of soil, variations in water content of the soil, are both additional potent factors in modifying the rate of movement of the soil air.

While it is not known in an exact way how the atmosphere of the soil effects the position or certain other features of the root-systems of plants, it seems probable that in certain cases, at least, the effect is pronounced. For example, as has been shown above, the root-systems of the cacti without exception are placed near the surface of the ground. The roots grow in a soil horizon which is not the most moist, but, on the other hand, which although moistened first is also the first to give up its water, and it very likely is the optimum air content of the soil at a critical period which determines the superficial placing of the roots. It is a well-known fact that many bulbous plants require well-drained soil, which is probably only another way of saying that they thrive best in soils having good aeration. Two or three experiments may be cited which may be taken to substantiate the conclusions just stated. For example, there grows in the vicinity of Tucson a cylindro-opuntia (*Opuntia arbuscula?*) in which the root-system is fleshy, the roots having much the appearance of slender sweet potatoes. It was supposed at first that the fleshy roots of these species was a specific character, which, indeed, may be true, and therefore *obligate*. Some doubts, however, have been thrown on this conclusion from observations on another

species of opuntia (*Opuntia vivipera*) in which the roots of one and the same individual may be either fibrous or fleshy. Also species resembling *Opuntia arbuscula,* but possibly another species, which grows in the vicinity of Sacaton, Arizona, appears to have fibrous roots only. It has been found also that the seedlings of many cylindro-opuntias have fleshy roots. This last may be taken to be a temporary or juvenile stage, but probably is not, for reasons which will appear directly. With the above and other observations in mind, specimens of opuntias of several different species have been grown in saturated soils, with the uniform result that the roots formed in the saturated soil were fleshy. This result might be taken to indicate the immediate effect of an abundant water supply, but in the end it may be found that the result, in part at least, may be attributed to the air relation.

There is another relation which has not been referred to and which is of great importance, namely, the osmotic relation. This can be given briefly. A strong impetus to the study of this relation has recently been given by Fitting,[2] who has shown that the shoots of certain desert plants may possess a very dense cell sap, so concentrated in fact that an osmotic pressure as great as 100 atmospheres has been determined, which pressure may even be exceeded. In the cells of the shoots of ordinary mesophytes the usual pressure is said to be from 5 to 11 atmospheres. While it has not been shown that the cell sap of the root hairs of such desert plants as have high osmotic pressures in the cells of the shoots is isosmotic with them, yet it has been assumed that the roots of these plants contain a very dense sap, as is probably the case. There is an apparently direct relation between the dryness of the habitat and the concentration of the plant juices, by reason of which the desert plant can absorb water from an intensely dry soil. As a rule the highest osmotic pressures, therefore, are to be found among perennials living in the driest situations, and during the most arid seasons. From this condition it is of interest to note that it is probably those plants in which the generalized type of root-system is to be found, or a type approaching this, that possess the most highly concentrated cell sap, since it is plants having this form of roots, as was noted above, which occupy the most arid habitats. We may conclude from this additional evidence that, so far as the Tucson desert is concerned, it is not the most deeply penetrating type of roots which are to be considered the desert form *par excellence,* but, quite the contrary, it is such a root as can both reach out widely and penetrate as deeply as the soil permits and in which there is developed a cell sap of extremely high concentration.

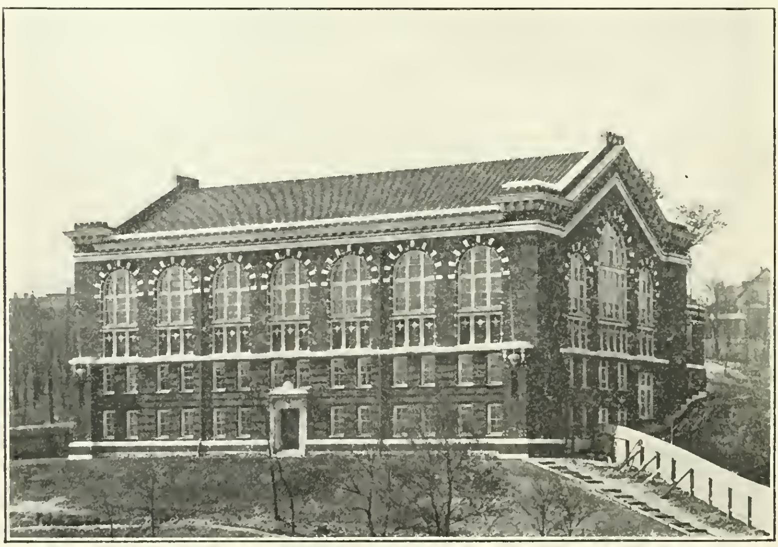
[2] "Die Wasserversorgung und die osmotischen Druckverhältniss der Wüstenpflanzen," *Zeitsch. f. Bot.,* 4, 1911.

THE PROGRESS OF SCIENCE

THE UNIVERSITY OF CINCINNATI AND ITS COOPERATIVE ENGINEERING COURSE

At its recent commencement exercises, the University of Cincinnati celebrated the opening of its new engineering building and the graduation of the first classes from the cooperative engineering course. The university itself and its cooperative engineering course are among the most interesting and promising educational experiments now in progress in this country. Cincinnati is the only city which maintains a municipal university. The state universities are the best witnesses that can be called in favor of our democracy. An institution such as the University of Wisconsin, liberally supported by the state and repaying many fold this support, covering the whole field of university work from the most special research to the most practical extension of knowledge among the people, has demonstrated what a democracy can do for a university and what a university can do for the state which maintains it.

But centralization and great size have their dangers. It seems to be neither desirable nor possible for the university of a state to provide education for all its citizens. There are at present about twenty thousand students in the universities and colleges of the state of Ohio. The number has doubled in the past ten years and will probably again double in the course of a decade; within thirty years it may be expected to be between one and two hundred thousand. Under these circumstances it seems to be necessary that not only the state but also the larger cities should maintain universities. The University of Cincinnati has demonstrated that this is feasible. At the beginning there may be neglect or political intrigue, but these are sure to be automatically outgrown as in the case of



The Gymnasium of the University of Cincinnati.

THE ENGINEERING BUILDING OF THE UNIVERSITY OF CINCINNATI.

the state universities. In the end the university is likely to become a center of civic pride, providing higher education locally and coordinating the libraries, museums and other institutions of the city.

The University of Cincinnati in June dedicated not only its fine engineering building, but also a gymnasium, the two buildings having been erected by the city at a cost of $550,000. At the same time President Dabney was able to announce that gifts from private citizens were the largest in number and the greatest in amount—about $250,000—ever received. There is no reason why private citizens and alumni should not give as liberally to a municipal or state university as to a private corporation, and we may expect to see a still more remarkable growth of state-supported institutions as the alumni increase in numbers, in wealth and in power.

One of the advantages of having local universities rather than only a central state institution is illustrated by the cooperative engineering course of the University of Cincinnati, from which students were this year for the first time graduated, and it is an interesting fact that the first experiment of this character should have been initiated by the first municipal university. Owing to the initiative and skill of the dean of the college, Professor Herman Schneider, arrangements have been made by which students work alternate weeks at the university and at commercial shops. The theory is taught at the university and the practise is obtained in the manufacturing plants. Students are paid for their work in the shops at the same rate as other men doing the same work, and no inconvenience is caused by the plan of alternate weeks as the men work continually in the shops in two relays. Students can thus practically support themselves while they are taking the engineering courses in the university. They probably learn more in the shops than by practical courses which the universities could arrange, and the shops obtain superior

men. The course is five years, and students probably can gain as valuable an education during this time as in four years wholly devoted to engineering studies. Night schools, extension courses, correspondence schools and the like are all useful, but the plan of working half the time at the university and half the time in practise seems to be superior to any other. There is no reason why the system should not be extended in other directions, as to teachers in the public schools of a city. The University of Cincinnati is certainly to be congratulated on having inaugurated a movement which demonstrates the peculiar usefulness of a municipal university.

THE ACTIVITIES OF THE CARNEGIE FOUNDATION FOR THE ADVANCEMENT OF TEACHING

The Carnegie Foundation has published a bulletin on medical education in Europe, prepared by Mr. Abraham Flexner, with an introduction by Dr. Henry S. Pritchett, president of the foundation, which, like its predecessor on medical education in the United States and Canada, issued two years ago, is a document of considerable interest. It appears that in the German Empire, in Austria and in France there is about one physician to each two thousand of the population, in Great Britain about one to 1,100, while in this country there is one physician for 568 persons. The distribution is naturally such that the supply of physicians is relatively much greater in the cities than in the country districts. This is a difficulty which, as Dr. Pritchett indicates, can probably be overcome only by some sort of state support. It is emphasized by the fact that the abler physicians are likely to be drawn to the cities, while it is in the country, where hospital facilities and specialists are lacking, that physicians are needed who are able to meet every emergency.

Mr. Flexner and Dr. Pritchett hold that the supply of physicians in this country is excessive and demoralizing, and place the blame on the large number and low standards of our medical schools. It is not, however, certain that in view of our greater wealth the supply is relatively larger than in Europe; nor is it certain that conditions would be greatly improved by suppressing the weaker schools. If it were possible to select in the right numbers the men best fitted to become physicians and to give them the best possible education, this would clearly be the most desirable state of affairs; but such ideal conditions do not obtain anywhere in our complicated civilization. Medical education is already so prolonged and expensive that if requirements are further increased the career will be open only to the rich; it seems necessary to train more physicians than are needed in order that the best may be selected, and it does not follow that those who are unable to support themselves as physicians are the worse for having had a medical education. It would be well if more children were born to fit parents and fewer to those who are unfit, and the apostles of eugenics are performing a useful service in preaching from this text. But the Carnegie Foundation places itself in the position of the practical eugenicist who would put unfit parents out of the way. This is a delicate and difficult undertaking, which one is scarcely prepared to entrust to Dr. Pritchett and Mr. Flexner.

The proprietary schools without proper laboratory and clinical facilities are probably being eliminated about as rapidly as is desirable. The American Medical Association publishes annually a list of those which are inadequate, and the Carnegie Foundation has given wide publicity to the deficiencies of these institutions. Such information is desirable, but it may be that the Carnegie Foundation is not the best agency to exploit it. Thus the foundation refused to give pensions to the professors of the University of Illinois at Urbana on the ground that its medical school in

Thomas Harrison Montgomery,
Late professor of zoology in the University of Pennsylvania.

Chicago did not maintain standards sufficiently high, and the university has just now abandoned its medical school. This may have been the best thing to do, but it seems undesirable that a private foundation should be able to dictate by purchase the educational policy of a state university.

The conditions are of such great educational and public concern that they should be clearly understood. The powers of the Carnegie Foundation may be illustrated by an example. It was originally established to grant pensions for length of service as well as for old age and disability. The length of service pensions were abandoned through lack of means, but the trustees, practically all of whom are university or college presidents, instructed the executive committee to "safeguard the interests" "of those whose twenty-five years of service includes service as a college president." Under this clause Dr. Wilson, when retiring from the presidency of Princeton University to be a candidate for governor of New Jersey, applied for the pension to which he was entitled by his services. The application was refused, and in some way information in regard to the matter was made public to Governor Wilson's political injury. The trustees at their last meeting rescinded the resolution in favor of the university president, and Dr. Pritchett states in his report that "no person has ever been retired under this authority." But the president of the State University of Iowa, not in an accepted institution and not eligible to retire for age, was granted a pension in August, 1911. The members of the executive committee of the foundation are in politics strongly opposed to Governor Wilson, and the secretary of the foundation was elected to the vacancy caused by the retirement of the president of the University of Iowa. Their action may have been altogether uninfluenced by these considerations; but they illustrate the dangers possible under a centralized pension system in which the pensions may be used by the president and the executive committee for ulterior purposes.

SCIENTIFIC ITEMS

We record with regret the death of Wilbur Wright, eminent for his achievement in the development of the aeroplane; of Dr. William McMichael Woodworth, of the Harvard Museum of Comparative Zoology, and of Dr. Ed. Strasburger, professor of botany at Bonn.

The Carnegie Institution of Washington has undertaken to publish the manuscripts left by the late Professor C. O. Whitman, including their preparation for the press and the maintenance and further study of the collection of pigeons that he left. Dr. Oscar Riddle is in charge of the work.—As a memorial of Professor Ralph S. Tarr a volume is to be published consisting of essays on physiographic and geographic subjects by men trained under him.—At a meeting of the London Institution of Electrical Engineers on May 16, a marble bust of the late Lord Kelvin was presented to the institution on behalf of Lady Kelvin.

Professor Theodore W. Richards, of Harvard University, has been awarded the Willard Gibbs medal by the Chicago Section of the American Chemical Society.—Dr. Franz Boas, professor of anthropology at Columbia University, has been given the doctorate of science by Oxford University.

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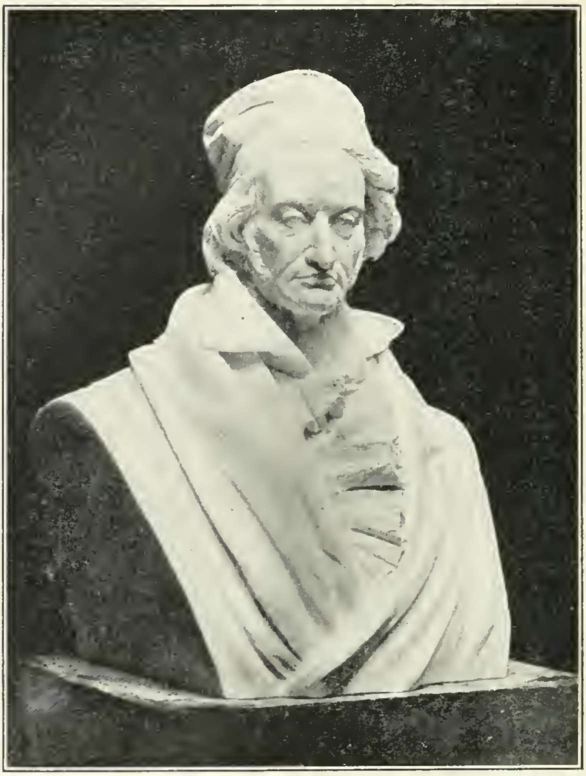
AUGUST, 1912

NOTES ON GAUSS AND HIS AMERICAN DESCENDANTS

By Professor FLORIAN CAJORI

COLORADO COLLEGE

UPON the Hohehagen, the highest mountain summit in the vicinity of Göttingen, there was dedicated on the twenty-ninth of July, 1911, an observation tower which commands an imposing and picturesque view of the university town of Göttingen, as well as of the ruins of proud medieval castles upon the mountain ridges beyond. This observation tower on the Hohehagen, now becoming a favorite objective point for excursionists, bears the name of a great scientist who made Göttingen famous. It is called the "Gaussturm" or "Gauss tower." Rising to a height of 120 feet, it overlooks all surrounding trees and objects. Within this tower is a room, called the "Gausszimmer," the chief ornament of which is a large marble bust of the great scientist, designed by the sculptor Eberlein. Another interesting exhibit is a reproduction of the Gauss-Weber electro-magnetic telegraph. It is well known that Gauss and Weber in 1833 had a crude telegraphic line between the observatory and the physical laboratory in Göttingen, a distance of 9,000 feet. This was eleven years before Morse sent his message from Washington to Baltimore, "What hath God wrought." Gauss and Weber employed, in signaling, the deflection of a galvanometer needle moving to the right or left. Henry and Morse in this country produced signals by an electro-magnet attracting an armature. While the Morse instrument is widely used in land telegraphy, the galvanometer needle found early application in ocean telegraphy. Germany has always prided itself on the Gaussian telegraph. On the Potsdamer bridge in Berlin there is a statue representing Gauss in a sitting position, watching with keen interest the deflection of the needle of a telegraphic instrument before him. By his side there is a youthful allegorical figure stretching a telegraphic wire around the globe.



Professor Eberlein's Bust of C. F. Gauss, recently placed in the Gauss Tower on the Hohehagen.

The Gauss tower on the Hohehagen indicates the exact location of a corner of a geodetic triangle in a survey established by Gauss. This triangle is classic in the history of geodesy. It was on that survey that the now famous instrument, invented by Gauss, called the "heliotrope," was used for the first time. It reflects the rays of the sun from one station to another many miles distant so that directions can be measured accurately and signals sent from station to station.

The high esteem in which Gauss is held in Germany is shown also by the recent dedication of another "Gauss room" in the town of Braunschweig. The house at No. 30 Wilhelmsstrasse, bears a tablet with the inscription: "In this house was born Carl Friedrich Gauss on April 30, 1777." The plan to establish in this house a "Gauss-zimmer" was carried out by the Historical Union of the Herzogtum Braunschweig. All sorts of Gauss relics have been gathered and are exhibited here. Photographs are shown of near relatives and the immediate descendants of Gauss, among whom are several Americans. Braunschweig has always been proud of its illustrious son. There is a statue of him in that city, on one side of which the close observer will

notice a regular polygon. This geometric figure recalls Gauss's first mathematical research, the discovery of a method of inscribing a regular 17-sided polygon into a circle by means of a ruler and a pair of compasses. On the Gauss bridge in Braunschweig a bronze celestial globe exhibiting the planet Ceres reminds passers-by of another great achievement of Gauss. Among astronomers his name first became known through his determination of the elements of the orbit of this planet Ceres from the observations on it made in 1801 by Piazzi in Italy. These observations were such that its orbit could not well be calculated by the old methods, and it remained for the genius of Gauss to devise a method of computing elliptic orbits which was free from the assumption of a small eccentricity and inclination. With the aid of Gauss's data the new planet was rediscovered by Olbers in Germany. Later Gauss gave much attention to modes of computing planetary and cometary orbits.

At the observatory in Göttingen, where Gauss carried on his great researches, there has been arranged in the rooms formerly occupied by

THE GAUSS TOWER ON THE HOHEHAGEN, NEAR GÖTTINGEN, DEDICATED JULY 29, 1911.

him a Gauss archive, in which the manuscripts of Gauss and other interesting material have been deposited. In the town of Göttingen there is a statue of Gauss and his friend Weber, the physicist whom we have mentioned earlier. Gauss, in a sitting posture, and Weber, standing, appear engaged in a lively scientific discussion. Besides the telegraph, Gauss and Weber designed instruments which were used in the early determination of the magnetic elements of the earth's magnetism. Through Gauss's initiative there was established the German Magnetic

THE HOUSE IN THE CITY OF BRAUNSCHWEIG WHERE C. F. GAUSS WAS BORN AND WHERE GAUSS RELICS ARE NOW ON EXHIBITION

Union, with the object of securing systematic and continuous observations. Important as were Gauss's achievements in geodesy and the earth's magnetism, his chief scientific researches were in mathematics and astronomy. During his labors at Göttingen, extending over nearly half a century, he made profound researches in the theory of numbers, which is one of the most subtle branches of mathematics. He greatly enriched by his investigations the theory of imaginary numbers, the

theory of equations, the calculus of variations, the theory of probability, the geometry of surfaces, and the subject of infinite series. Like Sir Isaac Newton, he at times displayed a disinclination to enter upon a prompt publication of his scientific deductions. As a consequence of this, others rediscovered and published results which Gauss might have claimed for himself. Thus it is now known that some of the discoveries on elliptic functions made by Abel and Jacobi had been worked out by Gauss thirty years earlier but not published. According to Professor Felix Klein, some Gaussian manuscripts reveal a knowledge of the fundamental ideas of quaternions, a subject fully elaborated later by the genius of the Irish astronomer, Sir William Rowan Hamilton.[1] Perhaps the most striking case of loss of priority of discovery due to failure to place his results at the disposal of the general scientific public, is that of non-euclidean geometry. For many years Gauss permitted his mind to dwell upon the subtle subject of parallel lines, and he reached some exceedingly original results. But he did not write down in full what he had worked out in his mind, and nothing was published by him on this topic. Off and on he would touch upon this subject in letters to scientific friends. He expressed to them his intention not to allow any part of this research to reach the general public during his lifetime. On January 27, 1829, he wrote to Bessel: "Probably I shall not be ready for a long time yet, to prepare for publication my very extensive researches on this subject and perhaps this will not happen during my lifetime, for I would dread the clamor of the Bœotians, were I to speak out in full." Imagine his surprise when the Hungarian Wolfgang Bolyai, a close friend of his during their student days at the university, sent a printed document of twenty-six pages written by Wolfgang's son, John Bolyai, in which the young Bolyai had worked out with wonderful clearness and originality the fundamental propositions of non-euclidean geometry. Gauss saw at once that he had been anticipated. How did the world-renowned mathematician of Göttingen behave toward the young and unknown Hungarian? Students of scientific history know that on questions of priority of discovery many a bitter battle has been fought. Scientific men are only human, and they frequently fail to see the full merits of rival claimants. But Gauss showed himself as generous as a man as he was great as a scientist. After reading John Bolyai's published dissertation, he wrote to his friend Gerling as follows (February 14, 1832): "I consider this young geometer v. Bolyai a genius of the first rank." To his old friend Wolfgang Bolyai, Gauss wrote (March 6, 1832) in this manner:

[1] Professor P. G. Tait declared that Klein is mistaken and that the Gaussian restricted forms of linear and vector operators do not constitute an invention of quaternions. Klein's article is in *Math. Annalen*, LI., 1898. A note by Tait appeared in *Proc. of the Royal Soc. of Edinburgh*, December 18, 1899.

Now about the work of your son. If I begin by saying that I dare not praise it, you will doubtless be startled for a moment. But I can not do otherwise. To praise it would be to praise myself, for the entire contents of the paper, the path which your son has pursued and the results which he has reached agree almost throughout with my own meditations, entertained by me in part since 30–35 years. By this I am surprised to the highest degree. It was my intention, during my lifetime to publish nothing of my own work, of which but little has thus far been put down on paper. Most people do not have the proper appreciation of the subject in hand and I have found only a few people who

THE STATUE OF GAUSS ON THE POTSDAMER BRIDGE IN BERLIN.

receive with interest the things I tell them. To be able to do so, one must have felt vividly what has been wanting, and on this point most people are quite in the dark. But it was my intention, some time to write down everything, so that it would not eventually perish with me. I am greatly surprised that I am saved this trouble and it is most pleasing to me that it is the son of my old friend who has anticipated me in such a remarkable way.

Would that all men of science could show the generosity toward rivals in matters of priority that Gauss showed toward John Bolyai. Gauss recognized the genius of Bolyai, gave him full credit for what he had done and gave up his own plans of preparing a paper on the new geometry.

Gauss lived nearly half a century at Göttingen in the midst of continuous work. In 1828 he attended a meeting of scientists in Berlin. After that he never left the vicinity of Göttingen, except in 1854, when a railroad was opened between Göttingen and Hanover. In the letter of August 7, 1852, which we print below in full, Gauss refers to his intention of going to Hanover, when the railroad is completed, and he says that he has not passed a night away from his own fireside since 1830. In marked contrast to this love of seclusion is the "Wanderungslust" of two of his sons, Eugen and Wilhelm. We shall see that both of them made their homes in the United States. A letter written by Wilhelm to his father in March, 1835 (kindly shown me by Mr. William T. Gauss, of Colorado Springs, Colo., a son of Wilhelm) discloses an intense longing to make his home in America, which country made uncontrollable appeals to his imagination. Wilhelm was then twenty-two years old and away from home. Here are fragments from the long letter on this subject:

> Father, I pray you again, by every earthly consideration, let me come home and next fall or winter go to America! I have written you that I can secure a position at Potsdam. . . . If you command me to accept it, then of course I must obey, but I can not remain there permanently. I have no peace day or night and in everything I do, America stands before my eyes! . . . Let me come home and study the English language during the summer, let me make the necessary preparations, and start in September of this year by way of New Orleans for Missouri.

He remained in Germany two years longer, devoting himself mainly to the study of agriculture, in preparation for the life he expected to lead in America.

Gauss had four sons, one of whom died in infancy. We have already mentioned Eugen and Wilhelm. Joseph, the oldest, was an officer in the German army, later a director of the Hanoverian railroads. In the latter part of the 30's he visited this country as a representative of his government to investigate the American railway system, then in its infancy. He maintained his residence in Germany, where later he assisted his father in the triangulation of the kingdom of Hanover. He died in 1873. His son Carl August Gauss, of Hameln, is the only grandchild of the mathematician who is living in Germany to-day. The United States now claims most of the descendants of Gauss. He had two daughters, who were married, but had no children. The older, Minna, married Ewald, the orientalist.

It is conceded that Eugen inherited more of his father's genius than did his brothers. Eugen left for this country as a boy of nineteen. Before coming he had been attending the University of Göttingen. While he was not more reckless than other students, he spent some of his time in fighting duels, enjoying the society of boon companions, and in doing whatever else made up the gay, yet not dissipated, life of a

Göttingen student of those days. The accounts of Bismarck's career give a good idea of what this life was. Upon one occasion Eugen gave a dinner to some of his student friends. Instead of paying for the score himself, he sent the bill to his father. When his father rebuked him for this, he took violent offence. Without mentioning the matter to either of his parents, he made up his mind to leave home and go to the United States. A day or two after that incident he left for Bremen to take ship for New York. Upon learning of this, the father promptly did his utmost to induce Eugen to return home, and, when failing in his endeavor, offered him money for the journey. Eugen remained in New York until his money was spent. Then he enlisted in the army of the United States as a private soldier. He was transferred with other enlisted men to a post at St. Peters in Minnesota. He had been there but a short time, when the officers of the post discovered that he was an educated man and, desirous of relieving him of the more onerous duties, placed him in charge of a small library at the post. After having served five years in the army, Eugen entered the service of the American Fur Co. and for about four years spent most of his time at Fort Pierre in South Dakota. It was about this time that his brother Joseph Gauss came to the United States to examine American railways. He brought with him letters of introduction to General Scott and other prominent men. He wrote his brother, offering to use his influence to secure him a commission in the army. This offer Eugen declined, as he had other plans laid out for himself. Shortly after a visit in 1840 to his brother Wilhelm, who had by this time come to America, Eugen settled in St. Charles, Mo., where he engaged in business. In 1885 he removed to a farm near Columbia, Mo., where he died in 1896. Whatever estrangement may at first have existed between Eugen and his father on account of his departure from home against his father's will was not of long duration. One of the letters received by Eugen from his father in Göttingen was written shortly after Eugen informed him of his intention to marry. It was cordial and affectionate. The original of this letter is now in the Lick Observatory.[2]

The youngest son, Wilhelm, came to America in 1837, with the consent and approval of his father. He went on a sailing vessel to New Orleans and from there traveled up the Mississippi to Missouri. Just before leaving Germany, he had married Louisa Aletta Fallenstein, a niece on her mother's side to the mathematician Bessel. In the published Gauss-Bessel correspondence mention of the young couple is frequently made. In 1855 he located permanently in the city of St. Louis, where he was engaged in the wholesale mercantile business until the

[2] For a copy of this letter and for additional details relative to the life and intellectual qualities of Eugen Gauss, as well as information relating to other descendants of C. F. Gauss in America, see an article, "Carl Friedrich Gauss and his Children," in *Science*, N. S., Vol. IX., 1899, pp. 697–704.

year of his death, in 1879. He was recognized as one of the representative business men of St. Louis. He was a man of great warmth of heart and of fine intellectual gifts. It may be mentioned that, when he went to St. Louis to live, he brought home with him a family of his slaves, as house servants. Before the civil war he freed all of them, starting the father as a hack-driver on his own account, by giving him a pair of horses and a carriage. To be an independent hack-driver was the ambition of many a southern negro of that time.

At the present time there are three grandsons of Carl Friedrich Gauss living in Colorado, four living in Missouri, and one in California.

The following letter (hitherto unpublished and now in the possession of Mr. William T. Gauss, of Colorado Springs, Colo.), penned by the mathematician Gauss only three years before his death, is of interest, not only because of what he says of himself, but also because of the references to social conditions and to some of his scientific friends. It is dated August 7, 1852, and is written to his son Wilhelm.

Lieber Wilhelm.

Ich kann nicht unterlassen, Theresens Briefe auch einige Zeilen von mir beizufügen.

Dein Schreiben vom 16 Januar (empfangen 26 Februar) hat mir mehrern Beziehungen viele Freude gemacht, ganz vorzüglich aber deswegen, weil daraus hervorgeht, dass Du in allen Deinen Verhältnissen mit Deiner Lage zufrieden bist. Wie wenige Menschen in Deutschland—oder soll ich sagen in Europa—können von sich dasselbe sagen! Inzwischen kann ich nicht läugnen, dass ich mir doch von Eurer Lebensweise kein recht (be)anschauliches Bild machen kann. Manches dabei wird freilich wohl (unendlich viel mehr als in der alten Welt) in beständig fortschreitendem Wechsel begriffen und jetzt ganz anders sein als vor 14 Jahren. Reisebeschreibungen durch Nordamerika gehen selten so weit nach Westen und so schwebten für mich die dortigen Zustände wie in einem Nebel. So möchte ich z. B. gerne wissen, ob die cultivirten Grundbesitze dort noch sehr zerstreuet, oder schon enge an einander liegen, ob unter den Besitzern viele Deutsche, oder ob es grösstentheils nur geborne Amerikaner sind, welche letztere in ihrer treibenden Unruhe wie ich glaube gewöhnlich nicht gerne lange an einem Platze bleiben, ob unter Deinen Nachbarn manche sind, mit denen Du freundschaftlichen Verkehr unterhältst, ob von den vielen Auswürflingen der letztjährigen deutschen u. a. Revolutionen oder Aufstände sich auch welche bis in Eure Gegend verschlagen haben. Das Auswandern nach Amerika überhaupt scheint noch mit jedem Jahre zuzunehmen; auch aus Göttingen hat eine Anzahl ihren bevorstehenden Abgang im Wochenblatt angezeigt, meistens sind es so viel ich erfahren habe nichtsnutzige Subjecte.

Über sonstige hiesige Verhältnisse wird Dir ohne Zweifel Therese ausführlicher schreiben. Ich selbst fühle mit jedem Jahre mehr allerlei Altersbeschwerden; doch habe ich in Betracht meiner Lebensjahre eigentlich kein Recht zu besonderer Klage. Zu den traurigsten Folgen eines hohen Alters gehört, dass immer mehrere unsrer frühern Freunde einer nach dem andern abscheiden. Schon Ende 1850 starb Schumacher. Am 14 Februar 1851 ganz unerwartet Goldschmidt, der noch den Abend vorher wohl und vergnügt bei mir gewesen war. Dieser Verlust hat mir lange viele Sorge gemacht, da mein eigner Gesundheitszustand mir wenig Theilnahme an den Beobachtungen in der Sternwarte erstattet. Ich habe jedoch für jetzt die Lücke recht gut wieder ersetzt, indem anstatt Eines Gehülfen jetzt

zwei (in Goldschm. Gehalt sich theilend) angestellt sind. Es sind ein Paar geschickte für das Beobachten eifrige junge Leute. Der eine davon (Dr. Westphal) hat schon das Glück gehabt (am 24 Julius) einen Kometen zuerst zu entdecken.

Meyerstein befindet sich wohl, und hat mich ersucht gelegentlich Dich von ihm zu grüssen. Eben so Dr. Ruete, der seit mehrern Jahren hier Professor u. besonders als Augenartzt sehr gesucht ist. Er wird aber Göttingen nachsten Michaelis verlassen, da er einen glänzenden Ruf nach Leipzig angenommen hat.

Die Aussicht, die Du mir machst, dass ich einmahl Lichtbilder von Deinen Kindern, oder einigen von ihnen (das jüngste wird wohl vorerst nicht so lange ruhig sitzen können) erhalten soll, erfreuet mich sehr. Einstweilen aber bitte ich Dich wenigstens die Geburtsjahre u. Tage aller Deiner Kinder mir zu schreiben. Ich weiss es bloss von dem letzten (1 Julius 1851) und dem Briefe Deiner lieben Frau an Theresen. Aus dem letztern sehe ich auch mit Bedauern, dass ein von meinem lieben ältesten Enkel an mich gerichteter Brief verloren gegangen sein muss, da ich einen solchen nicht erhalten habe. Wenn er in Deinen nächsten Brief einige Zeilen einlegen will, so soll es mich sehr freuen, und braucht er sich mit der Sprache gar nicht zu geniren, ich empfange sie eben so gerne wenn er english schreiben will.

An der Eisenbahn von Hannover nach Cassel wird recht thätig gearbeitet, auch in der unmittelbaren Nähe von Göttingen. Der Bahnhof wird vor das Gronerthor kommen nahe bei der Anatomie. Erlebe ich die Vollendung (hoffentlich in etwa 2 Jahr) so mache ich wohl auch noch einmahl eine Reise nach Hannover; meinen dortigen (3¼ jährigen) Enkel habe ich auch noch nicht gesehen. Seit Sept. 1830 habe ich keine einzige Nacht ausserhalb meiner vier Pfähle zugebracht.

Nun lebenwohl, mein lieber Sohn, mit Deiner ganzen Familie.

Stets Dein treuer Vater

C. F. Gauss

Göttingen den 7 August
1852

In the early part of the last century, when Gauss was still a young man, comparatively little attention was given to the mathematical sciences in Germany. In the words of a German scientist (Stern): "Germany of that day could say with the lioness in Æsop's fable: 'I have given birth to but one, but that one is a lion.'" Later in the century Germany could boast of many sons who command the lion's share of merit and distinction. The more recent German veneration for men of science and for matters pertaining to scholarship found expression in the remark once made by the Duke of Cambridge to Alexander v. Humboldt: "One frequently hears adverse criticisms of Göttingen, but as long as we have our library and Gauss, we can afford to let the heathen rage." Humboldt made the memorable reply: "I agree to this, but I must ask your Highness to interchange the order of the treasures and to give first place to the first mathematician of our time, the great astronomer, the genial physicist."

RESEARCH IN MEDICINE[1]

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IV. PRESENT-DAY METHODS AND PROBLEMS

THE important activities in scientific medicine at the present time may be said, without fear of contradiction, to be in the departments of (1) immunology,[2] (2) protozoology, (3) chemotherapy, (4) physiological chemistry, (5) experimental pharmacology and (6) experimental pathology. The methods and problems of these various phases of medicine it is my intention to discuss, some at length, others briefly, in the present lecture.

Immunology is the science which would explain and apply the mechanisms by means of which the animal body is enabled to resist disease. As has been shown, the efforts of bacteriologists until about 1890 were devoted almost entirely to the study of the etiology of the infectious diseases and to attempts to combat these by vaccination with attenuated viruses. Another phase of bacteriology was, however, already under way, and this, in the earlier nineties, not only yielded results of great practical importance, but opened a new and ever-widening field of investigation. This was the study of the mode of action of invading bacteria and their products, that is, of the process of infection and intoxication, and the mechanism by which the host combats the invasion and absorbs or cures such infection by overwhelming the foreign organism. One of the first results was the study of a group of soluble poisons, toxins—formed by certain bacteria and which it has been found are responsible not only for the symptoms which follow certain infections, but also for that effect on the cells of the host which stimulates the formation of the antibodies which we call antitoxins. Pasteur in his study of chicken-cholera had noticed that a bacteria-free filtrate of a culture of the specific microorganism of this disease could cause the symptoms produced by the bacilli themselves, but does not seem to have given much importance to the observation. Later (1888) two of his assistants, Roux and Yersin, found the same to be true of filtered cultures of the diphtheria bacillus. Later it was found that the tetanus bacillus and the bacillus (*B. botulismus*) of meat poisoning yielded similar soluble poisons.

[1] The Hitchcock lectures, delivered at the University of California, January 23–26, 1912.

[2] The use of this term is not perhaps above criticism, but its increasing use and need of some comprehensive word to cover the various activities represented by the term "studies in immunity," "serology" which in themselves are not adequate, are given as justification of its use.

Further study showed that the various bacterial toxins produce not only a fatal intoxication, but that each has its distinctive effect, as shown by symptoms or anatomical lesion, when injected into animals, thus demonstrating that the poison of each bacterium possessed a specific action. This led not only to a better understanding of the pathology of such diseases as diphtheria and tetanus, but eventually, and of far greater importance, to the discovery of curative and prophylactic sera, or as they are generally known, antitoxic sera. The first step in this direction was taken when Behring and Kitasato (1890) showed that animals could be immunized against weakened diphtheria toxin and that the serum of such animals is capable of protecting other animals against its intoxication, and, moreover, demonstrated that such a serum can be used to cure the toxic symptoms produced by the diphtheria bacillus. This curative power, furthermore, was found to be due not to an action on the bacteria, but to a neutralization of the toxin which the bacteria produced; also the serum was strictly specific, that is, the serum of an animal immunized against diphtheria toxin protects only against diphtheria; that prepared by the use of tetanus bacilli, only against tetanus. This led directly to the production by Behring and Knorr of diphtheria antitoxin for therapeutic purposes (1894) on a large scale and to a general awakening as to the possibilities of serum therapy. The great benefits of diphtheria antitoxin as a curative and prophylactic serum are known to all; since its general use, in 1896, a reduction of the death rate in diphtheria from 45 per cent. to 10 per cent. marks this therapeutic measure as one of the most brilliant discoveries of medicine and of the brilliant century in which this discovery occurred.

The success with diphtheria antitoxin aroused the hope that a general principle—that of the formation of antibodies for the toxins of all bacteria—had been established on the basis of which it would be possible to develop curative sera for all infections. This expectation—on account of the simple fact that most bacteria do not produce soluble poisons—has not been fulfilled; but the impetus which the principle of serumtherapy gave to investigation has led to activity of great and permanent value, and to the development of a new science, immunology or serology, as it is variously called, which attempts to establish laws for the conditions which determine natural resistance to infectious diseases and the factors which increase or diminish this resistance. I approach this subject with hesitation, for the many difficulties it offers can not readily be overcome in a short presentation such as this must be. A few brief statements, stripped of the less familiar terms may, however, serve to elucidate the main lines of investigation.

All immunological studies are based on the known fact of the reinforcement of natural resistance to disease, as illustrated by serum

therapy in diphtheria and by vaccine therapy in anthrax. The attempts to elucidate the principles underlying these two methods have led to the development of many fruitful hypotheses and theories, and many diagnostic and curative procedures of great value. It was early evident that the explanation of resistance to infection, either natural or acquired, must be sought in the cells or fluids of the body and especially of the blood. Metschnikoff (1884) was the first to show the importance of the white cells of the blood in combating infection through their power of engulfing and dissolving bacteria, and his pupils have supported his views, both as to the direct and indirect influence of these cells, the leucocytes, in the production of immunity. On the other hand, since Nuttall, in 1888, demonstrated the bactericidal power of the fluids of the body, and particularly of the blood serum, the relation of the body fluids to infection and immunity has been incessantly studied. As a result, schools have arisen, some supporting the cellular theory and others the humoral theory, and still others combining both theories in the attempt to reach an adequate explanation of the process of immunity. With these schools are associated most prominently the names of Metschnikoff, Ehrlich and Bordet.

One of the earliest and most important observations, after the discovery of antitoxins, was that of Pfeiffer (1894). This was the demonstration that a guinea-pig, into which has been injected the spirillum of cholera, develops in its body-fluids a substance capable of dissolving the cholera spirillum. This bacteriolytic substance is specific, that is, it destroys only the cholera spirillum; and Pfeiffer and his followers, pushing their investigations further, found that this principle of a specific lytic body could be applied to other bacteria and to foreign animal cells as well. Its development led to great advances in the theory of immunity, to the development of the fruitful hypothesis known by Ehrlich's name, and to the production of antibacterial sera, *e. g.*, antistreptococcus serum, as contrasted with antitoxic sera.

Likewise, it was discovered that the serum of animals receiving injections of a given bacterium had the power to agglutinate this organism; and moreover that this principle held good for the blood serum in certain diseases of man. Upon these observations was based (1896) the serum (Widal) reaction for typhoid fever, a definitely specific and reliable diagnostic method which has been followed by many other valuable tests based on the same principle and grouped under the general head of serum diagnosis.

At the same time older procedures were not forgotten, as is shown by Haffkine's extension of Pasteur's principle of vaccination to include protective vaccination against cholera (1893) and plague (1896) and more recently Wright's application of it to typhoid fever. Thus the last decade of the nineteenth century is marked by the birth of both serum-

therapeutics and serum-diagnosis and by the extension of the idea of preventive inoculation. As may readily be seen, the fundamental observations of Pasteur, of Behring and of Pfeiffer had been elaborated into some of the most serviceable principles, acknowledged at the moment, in the science and practise of medicine. Nor is this influence a matter of the past. In our own day has been established the theory of specific precipitation of foreign proteins (Uhlenhuth, 1901). This has led to the elaboration of a specific test for the differentiation of both vegetable and animal proteins, a method which has been adopted for the determination of species, not only in bacteriology, but also as a medico-legal test for determining the origin of blood stains and as a general biological procedure.

So also, through the work of Denys and later of A. E. Wright, a body has been recognized in the serum which had the power to prepare bacteria for ingestion and digestion by the leucocyte. To this body the name of opsonin or tropin has been given. You will remember that Metchnikoff discovered the fact that the white cells of the blood have the power to engulf bacteria, Wright supplemented this conception of demonstrating that a substance in the serum could so affect bacteria that they would be taken up more readily and in greater numbers; also he demonstrated that this opsonic power of the serum could be increased, and as the results of his teachings a definite opsonic therapy has developed. This treatment depends on the principle of vaccination with bacterial products. Before Wright, with the exception of Pasteur's treatment for hydrophobia, vaccination was used as a preventive measure only, but the studies which his observations have stimulated have led to very satisfactory results in the treatment of certain local infections as those due to the pus cocci and colon bacillus. Also, these studies have extended the practise of immunizing vaccination, as a prophylactic measure with, it has been claimed, most favorable results in the prevention of typhoid fever. For example the sanitary record of the maneuver division of the United States Army recently stationed on the Mexican border shows that in a body of 8,097 enlisted men, careful sanitation and antityphoid inoculation prevented almost entirely the occurrence of typhoid fever; only one case of typhoid fever was observed, and it was not fatal; while at the same time in the near-by city of San Antonio 49 cases were reported. Comparing the record of the maneuver division with that of a division of the Seventh Army Corps stationed at Jacksonville, under quite similar circumstances in 1898, we have one case of typhoid among the 8,097 men of the former and 2,693 undoubted cases among the 10,759 men of the latter division. It must be admitted in regard to this record of the maneuver division, that it is difficult to say to what extent the excellent showing was due to careful sanitation and to what extent to the antityphoid inoculation,

but past experience with troops in camp would indicate that inoculation was an important factor at San Antonio. The question of the value of preventive inoculation is, however, still an open one. So also are other applications of the principles of immunity, as the production of anti-sera for snake-venom, and for the irritant (and perhaps intoxicating) vegetable agent causing hay fever.

I have earlier in this lecture referred to methods of serum diagnosis depending on agglutination or solution of bacteria or on the precipitation of protein. Immunology has recently contributed to medicine another diagnostic method of great value. Its principle is that of complement fixation, the theory of which is too complicated for brief explanation, but the method as applied to syphilis, in the well-known Wassermann test, has since 1906 occupied a most prominent position in the diagnosis and treatment of this disease, and is now accepted as a method of great value in the more obscure cases, and numerous attempts are being made to apply the principle to other diseases.

Another phase of immunological study is that of anaphylaxis, a subject concerning which the professor of pathology in this university is one of the best known authorities. Anaphylaxis, the condition of increased susceptibility dependent on the sensitization of an organism to a foreign protein, is by no means thoroughly understood, but it has thrown light upon immunity from a new angle and has stimulated an enormous amount of investigation. Its utilization in the detection of specific proteins, its apparent explanation of the tuberculin, mallein and similar reactions, the light it has thrown on serum sickness, so-called, and the possibility it offers of explaining diseases characterized by critical phases, have attracted a host of investigators, who see in it the key to many little understood phenomena of disease. As yet the practical results are meager, but the ultimate outcome promises much for medicine.

Another field, and one in which American investigations have been of the greatest importance, is the study of diseases the etiology of which is unknown, but which, it has been supposed, are in some instances due to filtrable or ultramicroscopic viruses. The recent work on poliomyelitis by Flexner and his associates is an example. This disease, appearing irregularly in sporadic and epidemic form, was in the past not definitely grouped among the infectious diseases. All attempts to find a causative microorganism have failed. The workers of the Rockefeller Institute and also certain European investigators have shown that the tissues of the central nervous system contain the virus, and that when the fluids of such tissues are injected into monkeys, typical poliomyelitis results. Moreover, the experimental evidence points to an elimination of the virus through the upper respiratory passages, thus offering a substantial basis for scientific prophylaxis through the proper care of the secretions of the nose and throat. Such investigations show how im-

portant the methods of immunology are, for here we have a disease which, as the result of the application of such methods, is definitely placed among the transmissible diseases and is given a satisfactory theory for prophylaxis in spite of an utter absence of knowledge concerning its causal agent. An analogy is seen in yellow fever, the microorganism causing which we do not know and for which we have no specific treatment, but which is controlled simply through our knowledge of its transmission by the mosquito.

While on the subject of Flexner and his work mention must be made of the most important contribution in recent years to our list of curative sera. the antimeningococcus serum. The production of this serum, which in the best form is the result of the labors of Flexner and his associates, is an accomplishment which, in reducing enormously the mortality of epidemic meningitis, is in itself a sufficient justification for the establishment of the Rockefeller Institute. The beneficial results of its use are very definite and the mode of its administration, by direct injection into the spinal canal, has been of great value in emphasizing the importance of the local treatment of localized infections.

Many other phases of activity in the field of immunity might be presented, but this brief and disconnected summary will, I hope, suffice to indicate something of actual accomplishment in this field, the main lines of present endeavor, and the many opportunities for future achievement. Much of present-day effort may not lead immediately to tangible results—an outcome not uncommon in medical research—but the volume of work in progress and the vigor with which it is being prosecuted promises ultimately the solution of the many problems of the infectious diseases.

The Investigation of Cancer.—In no field of medical science has the modern experimental method given greater results in a few brief years and offered greater promise for the future than in the study of that fatal and obscure disease, cancer. Owing to the brilliant initiative of Jensen in Denmark and Leo Loeb in this country, it has been shown that a form of cancer occurs in certain lower animals, particularly in rats and mice, that can be artificially transmitted from one animal to another of the same species. This fact has afforded a means of studying in detail the method by which a malignant tumor grows in the body and more particularly has thrown light on the resistance or immunity to tumor growth which may occur naturally in certain individuals and which may even be artificially produced. Scattered over the world are small groups of individuals, more particularly in England, in Germany and in America, who are devoting their entire energies to the solution of this problem. From several divergent sources have come published results of experiments which offer the greatest promise that we may soon learn a method of curing these tumors. Already Ehrlich

and Wassermann have shown the possibility of preparing specific cellular poisons for cancer analogous to those used in curing protozoan diseases. The final clue which will unravel the mystery of this complex disease would not appear to be as yet fully in hand, and yet I think no one of those most conversant with the problem would be surprised to find to-morrow that it has been discovered and that cancer was curable.

Protozoology.—It is of interest that about the year 1890, when bacteriologists ceased to announce discoveries with their accustomed regularity, owing to the fact that all readily recognized pathologenic bacteria had been discovered, the systematic study of protozoa began and some of the single-cell forms of life in the animal kingdom soon took a place as disease-producers alongside the corresponding form of the vegetable kingdom. Until this time, protozoa had been found in only two diseases of man, dysentery and malaria. In the year 1890 appeared the first books on the subject of protozoa as causes of disease, a small volume of one hundred pages by L. Pfeiffer, followed in the next year by Doflein's more extensive discussion of the same subject from the broader biological point of view. The bacteriologists of the preceding decade had by their efforts limited the number of diseases in which a bacterial etiology could be readily shown and it was natural, therefore, that the attention of investigators turned to the study of other micro-organisms as factors in the production of disease. The careful technique of the bacteriologist had shown the methods to be used in the study of etiology, and, undoubtedly, the publications of Pfeiffer and Doflein stimulated general interest in the search for pathogenic protozoa. However this may be, it is a matter of record that in 1890 "only two human diseases were suspected of being caused by protozoa. . . . To-day more than fifteen are known or suspected to be of protozoan origin" (Calkins).

In the discussion of bacteriology I have referred to Leeuwenhoek as the first to see bacteria; he was likewise the first to see protozoa (1675). Two hundred years later, Bütschli (1875) offered conclusive evidence of the unicellular nature of these minute forms of animal life. In the intervening period, however, owing largely to the work of O. F. Muller (1786), Ehrenberg (1833–38) and Dujardin (1835–41), many forms had been removed from the "chaos animalculæ," the name under which Cuvier had classified them and their structure had been studied by Siebold (1845) and Max Schultze (1863). In this later period also several forms now familiar to us as occasional parasites of man had been described; as the *Trichomonas vaginalis* (Donné in 1837), the *Cercomonas hominis* (Davaine, 1857), the *Balantidium coli* (Malmsten, 1857) and the *Lamblia intestinalis* (Lambl, 1859).

The first parasitic protozoon, however, to be definitely associated

with a specific disease of man was the ameba discovered by Lambl (1860), first observed in the human intestine by Lösch in 1875, and said by the latter to be the cause of amebic dysentery. In 1891 Councilman and Lafleur, after a very accurate study of this disease, as it occurred in Baltimore, came to the conclusion that two types of amebæ must be recognized; one, the *Ameba coli,* was harmless, another, which they called *Ameba dysenteriæ,* they claimed to be the cause of tropical dysentery. In this view they were supported later by the feeding experiments of Casagrandi and Barbagallo (1897) and of Schaudinn (1903); the latter also introduced the name *Entameba histolytica* for the pathogenic form, and *Entameba coli* for the harmless form. It has since been found that two forms of tropical dysentery exist, one of which, as shown by Shiga, Kruse and Flexner, is due to bacteria—but equally definitely has the etiology of an amebic form been established.

In the meantime another protozoan disease was being investigated. Laveran, a French military physician, stationed in Algiers, announced in 1880 that the dancing pigmented bodies frequently seen in the red blood cells in malaria were altered hemoglobin granules within a protozoon to which he gave the name *Oscillaria malariæ.* This name was altered by Marchiafava and Celli to *Plasmodium malariæ,* in 1885, and Golgi, in 1886, by demonstrating that the characteristic paroxysms of the disease coincide with the segmentation or sporulation of this parasite, settled definitely the question of its etiologic relation to malaria.

The work on malaria constituted a very large part of the activity in medical investigation at this time. Until the middle of the nineties, many investigators were interesting themselves in the study of the different forms of parasites concerned, their life history and the methods for demonstrating them; these activities, with the study of similar parasites in birds, gave a great impetus to the study of pathogenic protozoa, and prepared many workers for a wider field.

Nevertheless, but few were prepared for the wonderful announcement by Smith and Kilbourne, in 1893, of the transmission of a protozoan disease through a blood-sucking insect. In this, the work of our own countrymen, on a malaria-like disease of cattle, Texas fever, the tick was shown to be the carrier of the *Pirosplasma bigeminum,* the organism responsible for the disease. The importance of this observation can not be over-estimated. It was the finger-post indicating the way to progress in the study of the transmission, and therefore of the prevention, of protozoan disease, and to Smith and Kilbourne belongs the credit of this great advance, which, it must be admitted, had a great influence on the study of the transmission of malaria and yellow fever. Many suggestions had been made from time to time that these diseases might be due to transmission by the mosquito; and these theories became indisputable fact when Ross announced from India in 1897–99

that the malaria of birds was transmitted by a species of mosquito (*Culex*) and when Grassi, Bignami and Bastianelli (1898–99) likewise demonstrated that malaria of man is transmitted by another species of mosquito (*Anopheles*). But before this, Bruce's study (1894–97) of the South African disease of cattle, which you may remember Livingston refers to as the "tse-tse fly disease," resulted in the discovery of the protozoan origin of the disease and the importance of the tse-tse fly (*Glossina morsitans*) in its transmission.

Soon followed (1900–01) the discovery by the United States Army Yellow Fever Commission—Reed, Carroll, Agramonte and Lazear—of the transmission of yellow fever by a third species of mosquito, the *Stegomyia*, and in 1903 Bruce announced that the sleeping sickness of Africa, due to a trypanosome, is transmitted by the tse-tse fly (*Glossina palpalis*). So also certain closely allied diseases of the far east, known as dum-dum fever, kala-azar, oriental sore, etc., were shown to be due to protozoa and to be probably transmitted by an insect.

The importance of these discoveries for prophylaxis was far reaching. It had long been known that malaria could be cured by quinine, but physicians in face of constant infections and reinfections were helpless. Now, the knowledge that the disease is transmitted by a mosquito, and by but one genus of mosquito, the *Anopheles*, allows the health officer to step in and by draining the breeding places of the mosquito to destroy the agent of transmission or, if this is impossible, to prevent contact with the mosquito by screens and other mechanical means. As far as we know, the parasite of malaria exists only in infected man and in infected mosquito. Perpetuation of the disease is due to the perpetuation of the cycle, man to mosquito, mosquito to man. If the parasite is destroyed in man or the *Anopheles* is not allowed to breed, the disease disappears. Not only has this been demonstrated experimentally, but it is in many communities a commonplace of sanitation.

Yellow fever is a disease, the causal agent of which is unknown, but so carefully has its prophylaxis been worked out on the basis of its transmission by the mosquito, as a result of the work of Read, Carroll, Lazear and Agramonte, that an epidemic of yellow fever would now be considered as due to ignorance or criminal carelessness on the part of those responsible for the public health. It is unnecessary for me to remind this audience of the heroism of Lazear and his associates and of the non-immune enlisted American soldiers, who offered themselves for experimental inoculation through the bite of mosquitoes infected with yellow fever. To their labors we, as a people, owe the present magnificent progress in the Canal Zone, the absence of yellow fever in the Gulf ports, an increase in human comfort and happiness and an increase in national prosperity and national progress; but still more, to

them, as also to Ricketts, who investigated Mexican typhus and succumbed to it, and to Walter Myers and Everett Dutton, of the Liverpool School, our science owes much in methods and in ideals.

Truly, no field of medicine offers so much of tragedy, of romance and of spectacular discovery as that of the pathogenic protozoa, and few offer such great difficulties. It is, however, one of the most promising fields of present-day effort and one which I would like to present more in detail. It must, however, suffice to end this presentation with mere mention of the successful cultivation of amebæ (Mesnil and Mouton), the cultivation of the trypanosomes (Novy and MacNeal), the discovery by Schaudinn and Hoffman of the spirochete, which we now know to be the cause of syphilis, and the finding of a very similar organism in yaws. Time might also be given to the various trypanosomes, to the spirochetes causing diseases of cattle and poultry and to the Negri bodies of rabies; also the discussion might be extended to include the broader field of tropical medicine, but instead, as it is the direct outcome of the study of protozoa, I must turn to a new phase of research in medicine, that known as chemotherapy.

Chemotherapy

As the study of protozoan diseases progressed it soon became evident that the method of combating such diseases must be different from that used against diseases due to bacteria. The chronicity of amebic dysentery and relapses in malaria indicated that the protozoan diseases are not self-limited and therefore not characterized by the development of immune bodies, similar to those of the acute bacterial diseases; also artificial cultivation failed to demonstrate that protozoa yielded bodies analogous to bacterial toxins, capable of producing, on injection, bodies with efficient antitoxic power. These and other facts precluded, therefore, a therapy based on the principles applied to bacterial vaccines or antitoxins.

The beneficial effect of quinine in the treatment of malaria and the cellucidal action of quinine on the ameba and other protozoan forms indicated that a therapy, to be successful, must be one in which a substance toxic for the protozoa in question is brought into direct contact with it. The establishment of such therapy and incidentally the creation of a new science, that of specific chemical therapeutics, has been the work, in the past seven years of Professor Ehrlich, of the Royal Prussian Institution for Experimental Therapeutics at Frankfurt. This new therapy is based on the principle that "a specific chemical affinity exists between specific living cells and specific chemical substances." This principle has always been the main theme of Ehrlich's work, as is seen in his application of the aniline dyes to the

study of the cells of the blood, his studies on vital staining and the selective action of methylene blue on the nervous system, the use of methylene blue in the study of the oxidations and reductions occurring in tissues, and his extensive studies in immunity. This experience, covering a period of twenty-five years, led Ehrlich to the belief that "for each specific parasite a specific curative drug must and could be found." And upon this assumption he began his experiments.

To appreciate thoroughly the difficulties of this task and the magnitude of the results, it must be understood that Ehrlich proposed a sterilization of the body in so far as the microorganism, against which the specific remedy was aimed, was concerned. The destruction of bacteria or protozoa outside the body by chemical means is a commonplace of surgical and public health measures; but the destruction of living microorganisms within the living body had never, until Ehrlich accomplished it, been possible without, at the same time, destroying also, in part or in *toto,* the cells of the host. To avoid the latter it was necessary, therefore, that the protozoa-destroying substance should have a specific chemical affinity for the protozoa in question, but little or no chemical affinity for the cells of the host.

It is impossible to give the details of Ehrlich's seven years of work on this problem; a brief description of the main results must suffice. The first work was done with trypanosomes, the mouse, which could be readily infected, being used as an experimental animal. After testing, with the aid of his assistant, K. Shiga, many hundreds of dye-stuffs, some old and some new, one, a member of the benzidin group, was found which retarded the progress of the trypanosome infection for several days. This led to a limitation of the experimentation to a study of the synthetic products of the benzidin group, many of which were made for the first time by Ehrlich and his assistants. The result was the discovery of a substance which exerted an actual curative effect upon trypanosomiasis. This substance, a red dye destroying trypanosomes, was given the name trypan red (trypan roth). If twenty-four hours after mice had been infected with the trypanosome of *Mal de Caderas,* a single injection of this dye was made, animals which ordinarily died in four to five days went on to permanent recovery. The blood, twenty-four hours after injection, was found to be free of trypanosomes, which indicated that the effect of the injection was to destroy absolutely every infecting protozoan. Thus was demonstrated for the first time the possibility of completely sterilizing the animal body by a chemical disinfectant without injury to the cells of the host.

In the course of this work an interesting observation was made. If, instead of a dose necessary to destroy all the trypanosomes, a slightly smaller dose was injected, the trypanosomes would disappear from the circulation for a short time and later reappear. If such

injection was repeated at intervals, the period of disappearance of the trypanosome would gradually shorten until finally the drug would have no effect on the infecting organism; in other words, a strain of trypanosomes had been developed which were resistant, immunized as it were, to trypan red and this resistance could be transmitted through many generations. Also, it was found that trypan red was a curative agent only for the infection in mice; on the trypanosome diseases of larger animals, as horses and cattle, it had no curative effect. However, the experience with trypan-red pointed the way to a solution of the difficulty; either a drug must be found which by a single injection would kill every parasite, or several different drugs must be used, which, acting on the same parasite, and thus allowing a combination treatment, would lead to a cure without the danger, to the host, of a single massive dose. It is impossible in the scope of these lectures to follow in detail Ehrlich's work or to go into the complicated chemistry of the substances used. It must suffice to say that as the work went on, Ehrlich and Weinberg found a substitution produced of trypan-red, amidotrypan-red, which destroyed the virulent parasite of nagana, the tse-tse fly disease, and that Mesnil and Nicolle, using the blue and violet azo-dyestuffs, prepared a trypan blue and trypan violet which caused the disappearance of the parasites of nagana, surra and mal de Caderas.

Another line of progress was through various combinations of anilin with arsenic. Before Ehrlich entered this field, Bruce had found arsenic to be a drug of value in treating the trypanosomiasis of horses (surra) and Thomas had found that atoxyl, a combination of arsenic and anilin, would cure a large percentage of infected animals. This latter substance had also been used in the treatment of the human disease, sleeping sickness. Ehrlich made a thorough study of arsenic compounds, and the result was the combination, arsenophenylglycin, a single dose of which absolutely and permanently cures all animals suffering from trypanosome infection.

At about this stage of the development of chemotherapy, Uhlenhuth and Salmon published an account of the brilliant use of atoxyl in the treatment of syphilis, which as we have mentioned, is due to a protozoan, the spirocheta pallida. Unfortunately, as atoxyl sometimes caused blindness, its use was not without danger and therefore not desirable. So Ehrlich immediately turned his attention to the protozoan diseases caused by spirilla, as chicken spirillosis, relapsing fever and syphilis. His labors on these diseases constitute one of the most fascinating of modern laboratory studies and his results are among the greatest of scientific discoveries. His intimate knowledge of the constitution of atoxyl and other arsenic preparations allowed him to proceed rapidly with "a great variety of substitutions, and innumerable arsenic derivatives were synthetized." As human syphilis could be

transmitted to the rabbit and relapsing fever to the mouse, the power of these preparations, as soon as manufactured, could be tested in the laboratory. The object, of course, was to find a substance which would kill the spirochetes without injury to the host. The result was the justly celebrated Ehrlich-Hata 606, chemically known as dioxydiamidoarsenobenzol, sometimes shortened to arsenobenzol, and, more recently, receiving the commercial name, Salvarsan. This substance in a single dose, 58 times smaller than the *dosis tolerata* (the largest dose which could be given with safety), cured definitely chicken spirillosis; a single small dose destroyed the spirolla of relapsing fever in infected mice, and a single injection of one seventh the *dosis tolerata,* caused the spirochete of syphilis to disappear completely from the experimental lesions of the rabbit within twenty-four hours. This last experience naturally aroused the hope of curing syphilis in man by a single injection given in the early stages. Such treatment, if successful, would supersede, or at least supplement, the empirical treatment by mercury which required a course of several years' treatment before a cure could be assured. The toxicity of the substance was, therefore, tested on dogs and then, to make sure it had no ill effects, on healthy men (assistants of Professor Alt), who volunteered for the purpose and finally the therapeutic effect was tried on relapsing fever in man. Iversen, of Russia, to whom this work was entrusted, found that one injection completely cured relapsing fever in 90 per cent. of his patients. Finally the substance was used in the treatment of syphilis in man. The completeness and rapidity of the curative action have been astounding. The effect on the lesions of the primary and secondary stages is to cause them to heal or disappear promptly; the spirochetes can not be found after a few days and the effect is apparently one of complete sterilization. Thousands of reports in the medical press confirm the general beneficial effect of this remedy and testify to the absence of ill-effects when properly administered. Even though further experience may modify the present optimism, nothing can detract from the magnificent service by which Ehrlich and his pupils have benefited humanity and added to the glory of medical science by establishing the principle of specific chemotherapy. With a record of about a dozen drugs[2] which can be used to cure or modify diseases caused by nearly a dozen different protozoa,[3] chemotherapy offers promise of results which, with serumtherapy and vaccination in bacterial diseases, will sharply limit the ravages of the transmissible diseases of man and animals.

[2] (I.) The arsenic group: arsenious acid, atoxyl, acetylatoxyl, arsenophenylglycin and dioxydiamidoarsenobenzol. (II.) Azo-dyestuffs: trypan-red, trypanblue and trypan-violet. (III.) Basic triphenylmethan dyestuffs: parafuchsin, methyl-violet and pyronin.

[3] Nagana, surra, sleeping sickness, mal de Caderas, Texas fever, chicken spirillosis, relapsing fever and syphilis.

Here we must leave the story of the infectious diseases, which has occupied our attention from the beginning of the third lecture to this point, and turn to a brief discussion of other methods of modern research in medicine, those of physiological chemistry, pharmacology and experimental pathology, which had their beginnings in the subjects (chemistry, physiology and pathology) discussed in the second lecture. The presentation must, however, necessarily be but brief and fragmentary, a mere summary, in fact, of aims and methods.

Physiological Chemistry.—The beginnings in this most important field of research were in Liebig's exact methods[4] for the study of organic chemistry and Wöhler's studies which are famous on account of his synthesis of urea. It is usually stated that the cultivation of physiological chemistry as a distinct science, with independent institutes of its own, dates from the eighth decade of the past century, when Hoppe-Seyler in 1872 established his laboratory at Strassburg and in 1877 founded the *Zeitschrift f. physiologische Chemie.* But although this period does represent the first attempt to sharply separate laboratories of physiological chemistry from those of organic chemistry, on the one hand, and of physiology, on the other, the first independent chair of physiological chemistry was established as my colleague, Dr. John Marshall, informs[5] me, at the University of Tübingen in 1845 and was held by Eugen Schlossberger; likewise Schlossberger's laboratory was the first one to be devoted exclusively to the study of physiological chemistry. It was to this chair that Hoppe-Seyler was appointed in 1861, and which he held until shortly after the close of the Franco-Prussian war, when he accepted a similar chair in the University of Strassburg.

[4] These appeared in the following publications: "Instructions for the Chemical Analysis of Organic Bodies," 1837; "Chemistry in its Application to Agriculture and Physiology," 1840; "Animal Chemistry or Organic Chemistry in its Application to Physiology and Pathology," 1842; "Handbook of Organic Analysis," 1853. (Dates taken from early English translations.)

[5] Dr. Marshall's notes on the development of physiological chemistry at Tübingen are as follows: "In 1816 Dr. Med. George Kark Ludwig Sigwart at the request of the Medical faculty of the University of Tübingen delivered from time to time lectures on 'Zoochemie,' but notwithstanding that he was made professor extraordinarius in 1818 he was not provided with a laboratory. In 1835 the professor was given the use of quarters in the laboratory for agricultural and technical chemistry which was located in the old Tübingen castle. In 1845 Eugen Schlossberger, a pupil of Liebig and of Heinrich Rose was called to a professorship of physiological chemistry in Tübingen which was the first independent chair of physiological chemistry created at a German university and the laboratory was the first one to be established as a separate institution. From 1861 until 1872 this chair was held by Hoppe-Seyler when in 1872 he resigned to accept a professorship of the same title in the newly revived university at Strassburg. The laboratory in the old castle was occupied until 1885 when it was removed to the new building which had been erected for the subject."

Before and for some time after these events a great volume of work in physiological chemistry was done in laboratories of organic chemistry and of physiology; but the events at Tübingen and Strassburg served to concentrate attention on physiological chemistry and eventually to hasten the establishment of independent laboratories. For the first few years progress was slow; in 1882, to quote Dr. Marshall again, only two such independent laboratories, those of Tübingen and Strassburg, existed in Germany. In the intervening thirty years the situation has changed. Now, such laboratories exist wherever adequate teaching or intelligent research in medicine is attempted.

The early physiological chemistry was quite different from that with which we are familiar to-day. It was largely the analysis of the chemical composition of various body tissues and fluids. This early conception, however, soon gave way to a dynamic conception, the idea of function, and present-day investigators in physiological chemistry are concerned chiefly with the ways and means of cell action. The chemical constitution of the cell, its enzymes, the methods by which it builds up complex bodies from simple substances, or disintegrates a compound to its simplest constituents; in brief, the problems of digestion, metabolism and secretion in health and disease. These are the problems which concern this science and which, as its methods have been extended to include the study of the vegetable kingdom, as well as the lower forms of animal life, is now more frequently known by the broader term, biological chemistry. The dynamic point of view which to-day characterizes physiological chemistry is largely due to two influences which have come from the outside: (1) The study of intramolecular structure as carried out on the sugars, purins and proteins by the Fischer school, and (2) the study of the nature of chemical reactions, as taught by the modern school of physical chemistry, led by van't Hoff.

Its fundamental problems which during recent years have engaged the attention of its best workers and which still hold their attention are (1) the chemical composition of the protein molecule, (2) the part played by ferments or enzymes in the metabolic changes which occur within the cell and which are responsible for the functions of the various organs and tissues, (3) the general problems of nutrition and the relative values of different food-stuffs, (4) the question of the interrelation of function, that is, of the influence of the secretion of the cells of one organ or tissue on the cells of a remote organ or tissue, (5) the mechanism, from a chemical point of view, of natural and acquired resistance to disease and of phenomena associated with such resistance.

All of these investigations, it is seen, have for their object a better knowledge of the mechanism of cell activity.

Experimental Pharmacology or pharmaco-dynamics, as it is sometimes called, applies the methods of physiology and chemistry to the

study of the action of drugs, poisons and other substances which may alter normal function. Its early development corresponds to the period of the application of exact experimental methods to physiology which, as has been shown in an earlier lecture, dates from about 1840. Buchheim, professor of materia medica at Dorpat, established in his own house, in 1849, a laboratory for the study of pharmacological problems; somewhat later this laboratory became a part of the University of Dorpat and was, therefore, the first laboratory to procure for pharmacology, recognition as a science of university rank. Furthermore, Buchheim in 1876 in the *Archiv f. experimentelle Pathologie und Pharmakologie* (founded in 1873) defined the methods and aims which have guided pharmacological work for the past thirty-five years. He also made the first classification of drugs according to their physiological action.

The proper study of pharmacology is all-embracing. It includes not only the study of the mode of action of remedial agents in healthy individuals and the influence on such action of various abnormal or pathological conditions, but, also, the effect of a great variety of substances, as bacterial toxins, the secretions of venomous serpents and the products of metabolism, in short, all animal, vegetable or mineral substances in any way capable of altering normal physiology. Moreover, the study of the effect of these various substances is not limited to man and the higher animals, but includes the use of the lower invertebrate forms, bacteria and protozoa. It is, therefore, an all-inclusive branch of biology, dealing with the "comparative study of the action of chemical bodies on invertebrate and vertebrate animals." Its achievements are of interest to physiology, to which science it has contributed much, both in method and in fact; to chemistry, in that pharmacology has added largely to the data concerning the interaction of cell and chemical substance; and to practical therapeutics, in that it presents new remedies, explains the action of old remedies and defines the limitations of drug-therapy. Finally it has a definite relation to the general public welfare in that, by its methods, it establishes procedures for determining the potency of therapeutic remedies, thus preventing, on the one hand, ill effect from a drug of unusual power, and, on the other, guaranteeing a remedial agent of standard strength.

Experimental Pathology and Pathological Physiology are branches of pathology and physiology which, combining the methods of both these sciences with those of chemistry, attempt, by the study of abnormal conditions experimentally produced, to explain the disturbance in function consequent upon cell or tissue injury or disturbances in physiological or chemical equilibrium. Combining as they do the methods of several of the medical sciences, and having for their object the elucidation of definite problems in clinical medicine, they are essentially the

methods of a science of clinical medicine and have aided materially in the advance of this branch of medicine.

Such are the methods and problems of present-day research in medicine. The history of medicine teaches us that new methods and fruitful hypotheses may be brought forth at any time; new diseases, on the other hand, can now be expected only through changes in social relations and practises or as the result of new industries. Advance, therefore, would appear to lie in the concentrated application of present methods to present problems and in the application of such new methods, as may be confidently expected to appear from time to time, in any science which is so actively cultivated as is the science of modern medicine.

In this narrative of research medicine I have grouped the various phases of my presentation about men or events. These, as Hippocrates and Galen in antiquity; Vesalius and his influence on anatomy; Paré and his observations in surgery; Harvey, Hunter and Haller and their more or less isolated discoveries in physiology; Morgagni and his observations in pathological anatomy; and Jenner and his discovery of vaccination, represent the epoch-making efforts of workers widely separated and more or less isolated. In the early part of the nineteenth century, Johannes Müller, Liebig and Rokitansky founded respectively the sciences of physiology, organic chemistry and pathological anatomy upon the basis of concentrated laboratory effort and gave to these sciences an impetus the result of which we recognize to-day in the importance which they have attained. The main line of advance, however, has been in the past 70 years, and was made possible by the study of cells, through (1) the work of Schleiden on vegetable cells and of Schwann on animal cells thus establishing the cell doctrine; (2) the application of this theory by Virchow to pathology, and (3) Pasteur's conception of the rôle played by microscopic cells in fermentation and his application of this to the etiology of disease. Out of Pasteur's work grew, the treatment of bacterial diseases by vaccines and antitoxic sera, and the increased knowledge of infectious diseases gained by the study of bacteriology, led to the search for protozoa as causes of disease and the demonstration of the etiological importance of the latter, led, in turn, to the development of Ehrlich's chemotherapy as a means of combating protozoan disease. But while this was the main line of advance we have seen how Pasteur influenced surgery through Lister, and how anesthesia, through the efforts of Morton came also to aid this science. So, likewise, physiological chemistry came into being, indirectly as a result of Liebig's work, but more directly as a result of the needs of physiology for a better understanding of cell composition and enzyme action, and, finally, both physiology and physiological chemistry con-

tributed to the establishment of pharmacology and experimental pathology. Medicine, in the sense of internal medicine, benefited by each and every advance in each and every one of its contributary branches, and, through the application of the principles of physics and chemistry to methods of diagnosis, gained its present large equipment of instruments of precision and means of exact interpretation; surgery in like manner gained the X-ray and many technical and mechanical procedures; and preventive medicine, utilizing the knowledge obtained through bacteriology, protozoology, immunity and chemistry, shares, with the science of engineering, the glory of promoting in greater degree than all other factors the social and industrial welfare of humanity.

The facilities and opportunities possessed by American universities for the continuance of this progress will be the subject of the fifth lecture.

MODERN THOUGHT [1]

By Dr. EDWARD F. WILLIAMS
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WHILE purely metaphysical writings have not ceased to attract attention, it must be admitted that public interest has been drifting away from them and busying itself with inferences drawn from the study of nature and with speculations based upon these inferences. Yet here a philosophy has grown up, taking the form ordinarily of the theories more or less striking which leaders in scientific studies have held concerning the origin and laws of the universe. Some of these theories express very clear and decided opinions concerning man, his origin, capacity and destiny. But all agree that he stands in close relation to the visible, and that he alone of all living creatures can exercise a real and an intelligent control over it.

In a review of the thought of the last century, or century and a half, one is compelled to begin with a recognition of a fact which the majority of scientists, some of them unwillingly, accept, that back of all that appears, ever has appeared, or ever will appear, is thought, the outcome of mind, intelligent, directing, self-controlling mind. It is through the exercise of mental power that the meaning of nature is discerned, that significance is given to facts which penetration into her secrets has revealed. Neither atoms nor their combinations are of the least importance unless there is mind to make use of this combination. When we observe the changes which are constantly occurring in the natural world we can not avoid the question, What has thought to do with them? What influence have these changes had upon thought, what part has thought had in bringing them about?

Passing over for the present scientific theories formed and held in America, in southern or eastern Europe, and confining ourselves to the three great centers of modern European thought, France, Germany and Great Britain, we shall not be far out of the way if we assert that the beginnings of modern scientific theories are found in England or Scotland and have been made by individuals working in isolation with little help and scant encouragement from government, or royal societies,

[1] See review and statement of various forms of scientific thought presented and discussed with great ability by John Theodore Merz in his "History of European Thought in the Nineteenth Century," two volumes, William Blackwood and Sons, Edinburgh and London, 1905. This is one of the most valuable books of the time.

or universities: that these discoveries on British soil, like those involved in the theories of Newton, Harvey and Young, were taken up in Paris by members of the Academy of Sciences and through the aid of the government and by means of a wise organization of students of science were tested and their value made known to the world. It is to LaPlace of the Paris Academy of Sciences, more than to any one else, that Newton's theories were made known and were at last universally accepted. Paris up to the middle of the nineteenth century was the most important center of organized scientific study in the world. It was here that the experiments of Lavoisier in chemistry were made, here that Cuvier, Arago and scores of other men introduced into their studies the methods of exact measurements and weights, brought scientific procedure to mathematical precision and stated results in mathematical formulæ. It was in Germany, in the universities rather than in the academies, that these results were recorded, and through numerous periodicals given to the world. Germany long has been, and still is, the country of year books in which the history and progress of each special science is carefully traced and preserved for the benefit of the scholar. In France pains were taken with the literary form in which scientific discoveries were published, and a popularity was thereby secured for them unknown either in England or in Germany.

Two factors enter into intellectual progress, the extension or increase of knowledge, and its condensation. Reports of discoveries in any department of learning must be reduced to their lowest terms, or they will not be read, much less studied and made of use. In its accumulations of knowledge the nineteenth century is unsurpassed, but in condensation of knowledge some think it inferior to the time of Pericles in Athens. Nor is it certain, others say, that during the Renaissance, Italy did not surpass anything done in our modern era, and many give the palm to France during the sixteenth and seventeenth centuries. But the nineteenth century has no rival in its success in discovering and marking out new and better methods than any previously known, for increasing knowledge. It was in that century that the important conception of the unity of knowledge became prominent. In the opening of the twentieth century the desire to discover truth has not lost in strength, but our students and thinkers are exceedingly careful in the examination of the criteria of truth, for they have learned that not all which seems true, or is proclaimed as true, is true and can be accepted as true. Still men of science are wont to speak of their methods of study as "exact," and to call their discoveries "exact truth." The truths involved in these discoveries are tested by being brought into contact with practical life, that is, tested by experience. In all this thought is present and prominent. It is the thinker in the laboratory, in the factory, in the new industry established as the outcome of years

of experiment, who is to be considered, the thinker whose aims and works give character to the age.

Attempts have been made from time to time by men who have felt themselves masters of the thought and learning of their era to bring these results together and unify them under some comprehensive term. Thus Herder in his "Ideas for the History of the Human Race" emphasizes Humanity as the proper subject of study, Humanity in the large all-embracing sense. To Hegel it was the *Geist*, or the spirit of an age which deserves attention. Lotze, a philosopher of great repute not long since deceased, believing that men are living in that sphere of the cosmos of which Humboldt wrote, directed the thought of his time to man as the chief figure of the universe, the microcosmus in the cosmos. Herbert Spencer, without denying the existence of the unknowable or the absolute, testified to his belief in the unity of all things by the prominence he gives in his writings to the social organism. This organism he admits may be, probably is, under the control of an intelligent power but of which we can, he thinks, have no trustworthy knowledge. In these efforts to find some single expression under which all knowledge may be grouped and estimated at its real value, the tendency of the age toward unity is seen. What is desired and sought for is some theory which may be characterized by a single term by means of which whatever is can be explained, or its meaning clearly set forth. Humboldt in the cosmos sought to describe and explain the striking features of the physical world from the standpoint of a philosophical traveler. Hegel wrote as an idealistic philosopher, as a descendant, though not a follower of Kant. Herder and Lotze were influenced by the poetry and the current philosophy of their time, while men like Du Bois Reymond, denying that they were under the influence of any guiding star, adopted as their motto Ignoramus, Ignorabimus, Dubetemus, Laboremus. Haeckel as a pronounced materialist is still trying to guess the meaning of the riddles of the universe. In his position he is valiantly and ably opposed by the spiritualist, Sir Oliver Lodge.

It is not easy to find a road which will take one through the diversified and often confused thought of a single age, or a race, to say nothing of the thought of all the ages. Here and there events are prominent enough to characterize a century, or several centuries. Such was the case in the history of the Hebrew people, the early centuries of the Christian church, the century in which the power of the Pope culminated, the age of the revival of learning, the era of the reformation, the period of the French revolution, the beginning of the still continuing tendency among the more intelligent nations toward self-government, the most successful example being our own republic. Yet as a thinking age the nineteenth century has no distinguishing title. If it had we might have been spared such philosophies as those of the

unconscious, or the unknowable, and many others whose life has been short. Still, careful investigation into the leading traits of past centuries often reveals the existence of at least one thinker, sometimes of several thinkers, whose ideas and accomplishments have given character and prominence to his century. Thus we have the century of Augustine, that of Scotus Erigena, that of Anselm, that of Thomas Aquinas, that of Lord Bacon, that of Rousseau and Voltaire, who in a time of comparative quiet really prepared the way for the strife and destruction of the revolution. Perhaps there are men now living, even if we do not recognize them, whose thought and deeds will in the distant future characterize our times.

It has been well said that thought runs from the exact mathematical form to the vaguest religious form, from demonstration to feeling, from knowledge to faith. By this it is not meant that faith does not lay hold of realities, but that its objects are not the objects which awaken and retain the interest of the man of science, or of the lover of exact thought. Philosophy occupies herself with the region which lies between that of science and that of faith. We have therefore three kinds of thought, scientific, philosophical, religious, or as Kant might express it, transcendental. These may be united in a mind sufficiently capacious, as they surely are in the divine mind, but of this union this is not the place to speak.

In Germany from 1800 to 1830, perhaps a little later, the chief interest was in philosophy, as well it might be when such men were living as Fichte, Schelling, Hegel and their illustrious pupils. In France it was in science, of which the results were set forth in books or reports whose literary form was well nigh perfect, when men like Arago, Cuvier and their associates in the Paris Academy of Sciences were in their prime. In England it was the influence of individual thinkers, appearing here and there, often unexpectedly. For a time the writings of Wordsworth, Coleridge, Southey, Shelley and later of Browning and Tennyson affected thought, as in Germany the writings of Schiller, Lessing and Goethe had done. In a certain sense, as Merz remarks, the century began and ended in a ferment of opinion. In England and Scotland Wordsworth, Coleridge and Burns are followed by Byron. In Germany Kant is followed by degenerate materialistic systems of philosophy which he would have abhorred, as well as by some that were idealistic which yet would not have won his approval. It will be observed that the destructive schools of philosophy introduce nothing that is entirely new to the thinking world. Yet the cultivated mind is seriously at work, so that as the century progresses new ideas are formulated and are proving themselves constructive in character. This the words employed indicate, *e. g.*, energy, its conservation or dissipation. The words, individualism, personality recall Lotze with

his theory of values, while phrases like Natural Selection and the doctrine of evolution recall Darwin and Spencer. Words and phrases alike point to a struggle for condensation of thought in terms so clear and simple that no one can mistake their meaning.

Inasmuch as science has become international and we no longer speak of it as French, English or German, but simply as science, something in which all seekers after truth have a common ownership, a few of those explanations of the universe may now be considered which "exact thought" has given. We may look first of all at the abstract views, four in number, which are ancient in their origin, mathematical in their form and are still ardently defended. These are what have been termed the astronomical view of the world, the atomic view, the kinetic view and the physical view. The latter is the explanation given by those who believe in energy as the underlying and directing cause of movements or changes in the universe.

The astronomical theory rests on the doctrine of gravitation and explains the phenomena of the world in which we live as well as the relation and movements of the heavenly bodies to each other by the assumption of its universal existence. Upon the principle that bodies attract each other directly as their mass, inversely as the square of their distance, Newton enunciated his law of falling bodies. Upon this same principle the tides were explained as well as the revolution of the earth on its own axis and round the sun, the rotation of the heavenly bodies around their axes and around the sun, their motion through space and the velocity of this motion. If gravitation is universally operative on the earth, why should it not be operative everywhere? Through aid of the calculus Newton was able to apply the law of gravitation with the utmost accuracy and by its application lay bare the secrets of the heavenly bodies.

Newton's principles were received more favorably in France than in England. Under the influence of Laplace and the Paris Academy of Sciences, in spite of the protest of a sceptic here and there these principles were, after thorough and somewhat bitter discussion, accepted as true in France, and in no long time in all Europe. On Newton's theory of gravity, the corpuscular explanation of light made its way in scientific circles. Light was believed to be a substance and its laws of reflection and refraction were explained by the law of falling bodies.

The discovery of magnetism in 1791, of the voltaic pile in 1800, and researches into the phenomena of electricity, together with a growing conviction that space is empty and that matter is composed of atoms and requires a void, weakened confidence in the astronomical theory as a full and satisfactory explanation of all the phenomena of the universe. No one denied the facts which Newton had brought forward. No one ventured to assert that gravitation does not act everywhere, or that its

application does not explain cosmic phenomena, though difficulties even here were suggested, but even if it account for the action of molar objects, *i. e.,* those objects which can be weighed, measured and handled, it does not answer the questions which are put to us by the world of atoms. The study of chemistry and the queries raised by its revelations compelled the defenders of Newton's theories as a sufficient explanation of all phenomena in the heavens and on earth to enter upon a renewed investigation of the basis on which they rest, and to give patient consideration to the phenomena of the atomic world. At length, and because some other action than that of gravity was needed to explain molecular phenomena, the relation of atoms to each other, the phenomena of magnetism and electricity, what is known as the atomic theory was suggested and very generally received, not, however, as setting aside any truths discovered by Newton or involved in the astronomical theory, but as supplementing it and accounting with something like reason for the molar and molecular phenomena which it overlooked or did not recognize as existing.

This atomic theory is not an entirely modern theory. Empedocles of Sicily, who lived in the fifth century before Christ, accepting four primal elements, earth, air, fire and water, explained their modifications and their actions one upon the other, by assuming the existence of two principles, love and hate, attraction and repulsion, which are constantly in operation and which create the forms we behold and account for all the activity in the universe. The atomic theory developed, far more fully than by Empedocles, by Democritus of Abdera of the same century and defended by him with a wealth of learning possessed by no other man of his time gained wide acceptance. In its modern form the theory secured recognition in France and Germany earlier than in England. The exact methods of chemists and mathematicians, first in France then in Germany, led to the belief that matter is not a single piece of something in empty space, but is made up of a multitude of individual and indivisible particles which only partially fill this space, which is filled by that indefinable something which we call ether and which we affirm to be necessary both for sight and hearing.

As chemistry was more earnestly and wisely studied, as the laws of the combination of so-called elemental substances were better understood, men of science became less and less unwilling to admit the inadequacy of Newton's theory of gravitation as an explanation of all phenomena and the more ready to accept a theory which explained, as it seemed to them, the movements in the molecular world, and which, if matter is composed, as was asserted, of atoms, might explain conditions everywhere. Berzelius of Sweden demonstrated the truth of the theory by his wonderful experiments. Dalton's theory of atomic weights was accepted as in harmony with what seemed to be facts. Van't Hoff discovered, so it is believed, laws governing the arrangement of elements

or atoms in space which are as regular and as important as those assigned by the astronomers to the movements and arrangements of the heavenly bodies. If bodies are formed out of elements that combine with one another on some fixed and definite principle, and not under pressure of the law of gravitation, if this combination is universal, then there must be some law more elemental than that involved in gravity to explain this combination, to account for the phenomena of magnetism and electricity, to explain the disclosures of the microscope in that molecular world which underlies all that the most delicate instruments can render visible. For these and similar reasons the atomic theory of the universe has been proposed. Yet it is recognized as exceedingly complicated and not without need of modification.

But while this theory is held by large numbers of eminent scientists, since 1860 the study of gases has brought about a modification of it and given birth to the kinetic theory of the universe—the old theory of Heraclitus of Ephesus adapted to modern conditions—viz., that all things are in motion. The experiments of Clausius of Zürich, of James Clerk Maxwell of Scotland, and the practical applications of their theories and his own by Joule of Manchester in the study of heat, made it clear that what seems to be the dead pressure of the gases is an apparent rest of particles which are in reality engaged in a constant and law-determined bombardment of each other.

These particles, it was shown, move laterally and with well-nigh incredible speed. It is motion which reveals this long-hidden secret of the gases. It is motion also which accounts for the rigidity of solid bodies. The theory of motion, based on the doctrine of gravity as set forth by Newton and his successors, was the foundation of astronomy. That theory received the support of Huyghens of Holland, of Euler of Berlin and St. Petersburg, the famous mathematician, and was accepted by Young, Count Rumford and Fresnel. Young's undulatory theory of light was made known to the world during the decade from 1791 to 1801. The kinetic theory, the theory of motion everywhere, motion directed, determined and controlled by fixed law, received hesitatingly at first, was steadily opposed by Laplace, but was at last made popular by Arago and Fresnel in France. The doctrine of the polarization of light proved, it is affirmed, by the interference of light waves, contributed to its acceptance. Still opinions even in the Paris Academy were unsettled and confused. Hence the offer by the academy of a prize for an essay which should consider this whole subject, weigh calmly conflicting theories, discover the truth or the falsehood in each one of them, and with all possible thoroughness subject this new theory of motion to the severest tests. At the request of the academy, but against his wishes, Fresnel undertook the investigation. He began his studies with the conviction that this new theory had little foundation upon which to rest. But after careful experiment

and profound meditation he was convinced of its truth, and gave his reasons for his changed opinions in an essay which received the prize and was read to the academy in 1819, but which for some reason was not published till 1826. The difficulty in explaining transverse vibrations was overcome by showing that polarized rays of light have laterality, and by showing how a stretched string vibrates. The mechanical difference between light and sound was discovered. The tremor which causes sound, it was shown, is in the elastic fluid which carries the movement forward. Without motion there can be neither vision nor hearing. As motion is required to explain the behavior of gases and that fact had been set forth clearly in the experiments of Clausius, Maxwell and Joule, the conclusion did not seem to be far fetched that motion exists everywhere, and must be considered in whatever explanation one attempts to make of physical phenomena. It was also discovered that bodies moving rapidly round an axis, when immersed in water or in any movable medium, cease their rotation and flow forward as other bodies flow in water. In 1857 Helmholtz and Lord Kelvin brought forward the vortex theory to explain cosmic conditions and to account for the formation of the planetary worlds. The studies and experiments of Faraday in electricity and magnetism seemed to favor this new theory of motion. It was shown that the medium which carries light and sound can not possess the ordinary properties of a solid, a liquid or a gas. Hence a demand for a medium in which everything may exist, through the aid of which all movements or vibrations may be conveyed. Careful studies discovered the velocity which particles of hydrogen, for example, obtain, and Faraday pointed out lines of force, afterwards called "tubes of force" by Hertz, along which in a magnetic field, the electric movement passes. These movements were measured mathematically and with such care and accuracy that not only is the course which electricity takes known but its velocity also. But even if electricity be displacement, and its track be accurately discovered and followed, no one pretends to know just what is its innermost nature or denies that future study may entirely change present opinions as to its nature and its laws.

It has been proved, scientists declare, that all forces of matter may be measured and expressed in terms of *energy* or motion. During the last twenty years the conception has been formed that light is an electric or a magnetic phenomenon. Luminous waves are short rapidly moving waves and difference in color is caused by difference in length and frequency. But what is most important in this theory of motion is that it is not necessary, as in the gravitation theory or the atomic theory, to believe in the theory of action at a distance. Bodies move because other bodies press upon them. We see and hear because some sort of motion brings the ether into connection with eye and ear. The fact of gravity is not denied. Nor is it denied that Newton's dis-

coveries in reference to its action in the physical world explain the motions and relations of the heavenly bodies, but it is affirmed confidently that the theory of universal motion or the kinetic theory removes more difficulties in the explanation of the phenomena of the universe than either the astronomical or the atomic theory. In passing, it may be mentioned that this theory of universal motion was taught not only by Heraclitus, but by Anaxagoras of Athens, who saw that with his well-nigh innumerable germs he could not solve the problems of the universe apart from motion, and therefore introduced into his system of philosophy, the nous, or intelligence, to give the first push to matter and impart to it the movement which he believed to be universal and without which life could not exist.

The fourth of the abstract theories employed to explain the universe is the physical theory or the theory of energy. By this theory we understand that whatever is or has come to be has been caused by the force or energy there is in matter. The astronomical theory fails to account satisfactorily for molecular activity and chemical affinity: the kinetic theory is set aside because it is based on dualism or the existence of matter and ether. What is true in these theories is preserved and the difficulties found in the application of each one of them are avoided by the use of the general term energy, a term under which, according to Young, all that is known in science may be expressed. Energy or force is that something in nature which can do work and be stated in terms of horse power. We speak of latent energy, of energy created by friction, by the fall of water, by steam, and, although we are unable to define it, we describe it as something everywhere present and able, when properly harnessed or directed, to do a certain amount of work.

While refusing to speak of energy as a property of matter and denying that it is matter in any true sense of the word, it is affirmed that its amount in the material world can neither be increased nor diminished, that while from a heated object a certain portion of heat departs in cooling, a fact which is described as *entropy,* the sum total of energy, whether in the form of heat or of some other force, remains the same. This truth is set forth by Helmholtz as the conservation of force, a doctrine which, while admitting that a particular form of energy may be changed into another form, affirms that the energy itself is neither destroyed nor diminished by the transformations through which it may pass. Energy is valueless unless capable of transformation. It is good for nothing till it is made usable. Hence the study of energy has been more constantly directed toward discovering methods by means of which its power may be employed for the welfare of mankind, than toward ascertaining its nature. We know that energy may be changed in form, that it now appears as heat, now as light, now as electricity, now as magnetism. Nor are these the only

forms it assumes. Having taken pains to conserve energy or to obtain it, the practical question is how to use it?

That energy is everywhere present, underlies all things, was affirmed by Young, Rumford, Black, Müller, Mohr, Liebig, J. B. Mayer, Joule, Carnot, Sir William Thomson, or Lord Kelvin. It was through their efforts chiefly that the theory gained acceptance. It began to attract notice during the first third of the century, although its acceptance even now is by no means universal. Faraday, Mohr and not a few others believed in the existence of something indestructible, connected with matter, yet independent of it, but Helmholtz and his school explain everything mechanically. Heat, for example, is a product of motion. Other natural processes explain other natural manifestations. This theory was brought forward and defended in great part by the Scotch school to which belong the illustrious names of the Thomsons, James and William, Rankine, Clerk Maxwell, P. G. Tait and Balfour Stewart. Working alone, Clausius, of Zürich, reached substantially the same results. Maxwell studied the energy of the electric magnetic field, Joule the energy of the electric current, Watt measured heat. The idea of the unity of all chemical combinations was suggested by Arrhenius, of Sweden, in 1886, who showed how to decompose chemical solutions by the use of the galvanic current. Without saying anything more of this physical theory which presupposes the universal existence of energy as a force in matter, if not a constituent of it, as something which can neither be created nor destroyed by human agencies, though it may, through its power of convertibility into various forms of power, be made extremely useful, we simply add that energy may be so accurately measured by the aid of mathematics that before it is called forth from its hiding place we can ascertain exactly what amount of work it will do. Merz says that this theory has been useful to science in at least four ways.

It has brought out clearer definitions of terms.

It has caused a revision and recasting of physical and chemical knowledge.

It has criticized existing theories from a new point of view.

From this new point of view fresh departures in the study of science have been taken.

What energy is we do not know. It appears as intensity and power to do work. Is it a substance, material in its nature? What need then of ether to carry the undulations which produce sound or vision? Whatever the answer to these enquiries and many others which might be raised, energy seems to be a regulative and a directive rather than a constructive principle. Energy is found everywhere, but it nowhere appears as creative, save in bringing particles of matter together in new forms, or passing itself from one form of existence to another without growing less in amount.

From this brief review of the abstract or mathematical theories which have been proposed to explain the universe, it appears that while no one can deny the existence of gravity wherever there is matter, or of molecular activity or of motion, or of energy, it is certain that no one of them fully explains the mysteries of the universe. We feel the need of something more, some force or principle, some intelligence underlying all that we can see or discover as existing by the aid of the most powerful instruments, not only to direct and control forces already acting in and upon matter, but to create them and set them in motion.

Passing from these abstract explanations of the origin and nature of the universe and the consideration of their influence upon thought, four other theories, which may be called concrete from the fact that they rest on that which is visible and tangible, the morphological, the genetic, the vitalistic and the psycho-physical, require our attention. These theories are descriptive in their character and are based upon studies in the field rather than in the laboratory or the museum. Abstract science has been of immense advantage to the world of industry, and its methods of investigation will not soon be given up, but the progress made in the descriptive sciences has been very great and not without influence upon mind and life, or, as Merz is fond of saying, upon thought. The conception of energy and descent has helped to break down old distinctions and to establish on a firmer foundation the conception of unity in nature.

Morphology seeks to study objects as a whole rather than in detail, and to study these as they are in nature, before they suffer from changes wrought by the hands of men. The morphologist wants to know things as they are, and why they are. He recognizes the differences in the forms which substance assumes and in the structure of bodies. He considers their relation to each other and to their environment, the effect of climate and of time. But it is the object as a whole rather than any part of it in which he is interested. Such a method of study can not fail to be popular. It appeals to the people at large. Its descriptions can be easily understood and appreciated. Such men as Humboldt, Linnæus, Daubenton, Buffon and Cuvier have been among its distinguished advocates. Natural objects, it will be remembered, may be spoken of as cosmical, molar or molecular. Cosmical or heavenly bodies are magnitudes of immense size in space; molar objects are the objects we can see and handle here on the earth; molecular objects are the objects which are too small for our vision or touch to discover. Cosmical bodies are infinitely large, molecular infinitely small. If all bodies are similar in their composition, as the discoveries through the spectroscope seem to indicate, then a description of the nature of molar objects may be applied to those which are cosmic or molecular.

In the study of nature from a morphological point of view there is need of wide travel. Humboldt in his "Cosmos" has given us the re-

sults of investigations in portions of the world not often visited, and thus has made contributions of inestimable value to science. The study of animals in zoological gardens, if not in their native haunts, and of marine life by sea-going expeditions, or in extensive experimental stations by the seashore, as in Naples, Plymouth, England, or Woods Hole, Mass., has given a new impulse to the study of zoology and biology. The study of forms, especially those that are living, has been of great advantage to the physician also. From the days of Galen till the present time efforts have been made to apply the knowledge of physical laws to bodily healing. Galvanism, electricity, the nature and effect of different foods, the study of animal heat, have been made use of by the physician.

It is to Goethe that we are indebted for the word morphology, which describes his ideas as to the metamorphosis of plants. He saw, even if indistinctly, the unity of plant and animal life and the possible unity of all departments of nature. Merz says:

> In the perpetual variety of change the morphological view tries to define those recurring forms or types which present themselves again and again, towards which all changes seem to revert, thus bringing some order into what would otherwise be disorder and confusion. . . . The object of morphology as distinct from that of classification is the attempt to describe, and if possible to comprehend and explain the relative similarity as well as the graduated differences of form and structure which natural objects present to our gaze.

Natural objects can best be studied where nature presents them, under conditions which enable one to see them as they really exist in nature. But the study of nature, as a whole, is often best carried on by a study of its departments. Haüy creates for us in his mastery of the forms of crystals, and of the laws of crystallization, the science of crystallography. It is but a step from crystals to minerals and fossils, thence to plant and animal life. It is not surprising that, following hints from various sources and from his own studies, Theodore Schwann, having established the cellular theory of life, should assert, as he did in 1840, the essential identity of animal and vegetable structure. Since then his special department of study has made vast strides and ere long the science of biology may embrace everything in nature that relates even remotely to life.

Cuvier, the comparative anatomist, while cherishing large views, yet believed in types, in the fixity of species, and explained the changes produced in the world of animal life, the world of fossils, of plants and minerals, by sudden convulsions or catastrophes, by means of which old types of life are destroyed and new ones introduced. In this theory he was opposed by Étienne St. Hilaire, who explained the changes observable in the different departments of nature as the gradual outcome of the forces of nature. In this view he had the sympathy of Goethe.

Morphology without the microscope to assist in its study would have

made little progress. At the beginning of the last century it was in a backward condition. Improvements in the microscope and in the knowledge of its use, the studies of such men as Amici of Modena, Lister in England, the botanists Hugo von Mohl and Nägeli, of Stokes, Lord Rayleigh and Helmholtz, and the skill of Professor Ernst Abbe, of Jena, who has at his back the celebrated firm of Carl Zeiss, have rendered an exact study of cell life or formation of the tissues of all the processes and conditions of life possible and of value. But if the study of geology morphologically has produced men like Lyell, if in botany we have the great names of the Jussieus and De Candolle, in zoology, of Daubenton and Cuvier, more and more clearly has it been seen that nature is after all a unit in her processes. In the new field of astrophysics in which so much use is made of the spectroscope there is hardly a science known which is not employed in its development.

Yet the morphological study of nature alone could not long be satisfying. The progress made in the study of biology, the publication of Darwin's "Origin of Species" and Herbert Spencer's suggestion of the "physiological unit," called attention away from the forms of natural objects, from their study as individuals or collectively, or in relation to each other, from their distribution in various parts of the earth, to the changes wrought in them through the lapse of time, or by water, fire or convulsions of nature, to the processes of their formation or growth. Thus their genesis becomes of even greater interest than their form or their distribution. Indeed even the morphologist feels that his method of interpreting nature would be more satisfactory if he were fully acquainted with the methods which nature employs in the introduction and support of life.

This theory, the second of those we are now considering, is known as the genetic theory—and so called from its dealing with life. This theory assumes that all things are in motion and are developing along many lines, yet after some real order, if not after a fixed and definite plan. The word *evolution,* so generally used in England to indicate this process, is not universally employed in France or Germany. Herbert Spencer has the credit and the responsibility of introducing the word evolution into English-speaking scientific circles and also for using the word *genesis* to set forth a purely mechanical conception of the universe.

What we desire to know and seek to know is, How have things come to be, what they are and what is their history in time? Leibniz in his tract "Protogaea," published in 1749 called attention to the part fire and water have had, as indicated by visible proofs of their action, in forming the surface of the earth. He suggested a thorough study of many localities in order that general and satisfactory conclusions might be reached. Kant, influenced as he admits by the theories of Thomas Wright, of Durham, as to the formation of the planetary system, pro-

posed a theory of the formation of the universe which was afterwards developed into that well-known nebular hypothesis which till within a few years has been almost universally accepted as a reasonable explanation of the genesis of the stellar world. This theory was strengthened by the study of paleontology in England, and of embryology in Germany. During the first half of the century it was thought by many that life repeats itself, comes and goes in well-defined circles, but this hypothesis was displaced in the second half of the century by a belief in the gradual development of all natural forces toward a certain end. Hence the introduction of the word evolution.

Hutton's opposition to the catastrophic theory in geology prepared the way for Lyell in England who was unwilling to accept the genetic theory without modification. Nor was he content to remain a morphologist. "The Vestiges of Creation," published in 1840, and written by Robert Chambers, of Edinburgh, favored the genetic theory and applied it to the cosmic molar and molecular phenomena. The book, valuable for its suggestions and for the discussions to which it gave rise, met with decided opposition in many circles on the ground of its materialistic views and its tendency to explain nature without any reference to the supernatural. For a similar reason the opinions of many German scientists were unacceptable in Great Britain.

Yet in spite of the weight which the names of Humboldt, Cuvier and Richard Owen carried, it became evident, about the middle of the nineteenth century, that the morphological theory alone would not satisfy the scientific world. Doubts began to be cherished as to the fixity and permanence of species. There was opposition to the catastrophic theories in geology. Sir Charles Lyell in his "Principles of Geology" suggests orderly development, though without breaking with the older theories. Herbert Spencer in his writings in the early fifties sees more clearly than most others the necessity of some such theory as that which was afterwards known as the theory of evolution, or the gradual development of all forms and all life out of a simple original substance. As early as 1759 C. T. Wulff, as a result of his studies on cellular structure and growth, had come to the conclusion that growth is by additions and gave the world his theory of epigenesis. His influence dates from the year 1812 and was made effective through the work of Schleiden, Schwann, Mohl and Pander, who led the way in the study of that scientific embryology of which Pander is accounted the founder. Through these studies and those of Haeckel, which came later, the essential identity of the cell in structure substance and growth in the vegetable and animal world, was established.

As Herbert Spencer had prepared the English mind for the views of Darwin, so Haeckel prepared the way for their favorable consideration in Germany and on the continent. The work of Lamarck and of Von Baer, of Königsberg and St. Petersburg, was also of importance. But

"The Origin of Species" with its principle of natural selection, its preservation of useful qualities, the influence of environment and heredity, gave the genetic theory strong support. The views presented by its illustrious author were set forth with such clearness and defended with such wealth of illustration as to make their rejection a matter of great difficulty. Even those who were most hostile recognized their importance as well as their revolutionary character. It was evident to nearly every scientific man that henceforth the world could not be explained upon morphological theories alone, and that some such principle as that of natural selection must be presupposed in order to explain the facts which in almost every department of scientific research were daily coming to light. Natural selection has been defined as "that process in life, automatic in its nature and action by which in the struggle for existence useful differences are preserved and those which are not useful are destroyed." It is under the operation of this principle Spencer believed, and sought to show, that species are formed and the various manifestations of life accounted for. Those who accepted Mr. Spencer's theories in full, with few exceptions, accounted for the origin and evolution of the universe on purely mechanical principles.

But the questions as to life itself, its nature and its origin, were not on this evolutionary theory fully answered. Granting that the lowest forms of life are connected with the cell, that life is manifested in its structure and through its growth, even on the assumption that matter and energy only exist, the question can not be pushed aside. Whence is the energy which brings life into matter, organizes it and imparts to it the power or ability under the laws of evolution to create, perfect and continue at pleasure, the forms in which it chooses to appear? Logically the genetic theory must explain the origin and continuance of life on mechanical principles alone. A theory in sharp contrast to the genetic or evolutionary theory, which for many minds reduces life to a mechanical process, is what Mr. Merz calls the vitalistic theory. This theory is becoming more and more prominent with the increasing interest in the study of biology. What life is, what is its origin, what are its processes, are questions to which as yet completely satisfactory answers have not been returned. Bichot (1771–1802) defined life as the "totality of functions which resist death," a definition which gives little information as to the nature of life, or its origin. Claude Bernard (1813–78) wrote "life is the struggle of living forces against the non-living." Since the publication of Darwin's book on "The Origin of Species," or more exactly since 1866, a tendency is to be noted which seeks to establish parallelisms between processes in organic and inorganic bodies. Lavoisier was one of the first to study life from a chemical point of view, and to explain respiration, nutrition and the generation of animal heat as a form of combustion. In

1783 he and Laplace reported the results of their investigations on the subject of life to the Paris Academy of Sciences, but had little to say about the nature of life itself. In 1839 the British Association requested Liebig to study the subject of biology, as it then existed, and report at a subsequent meeting all that was known about it. The report was thorough, valuable and gave great satisfaction, but shed no light on the origin and nature of life. Though a vitalist, Liebig gave less attention to the defence of this belief than to the applications of the principles of chemistry to economics, especially as related to agriculture. Here his efforts were epoch-making. John Müller, of Berlin, and the Weber brothers, of Leipzig, investigated the physical and mechanical processes of life, so far as they could trace them by careful experiment in the laboratory. Du Bois Reymond and Helmholtz were trained by Müller and were among his most distinguished pupils.

It was while seeking answers to questions which investigations as to the origin and nature of life were constantly presenting that Helmholtz and Meyer, in entire independence of each other, discovered the principle of the conservation of force or energy. In 1847 Helmholtz proved, as he thought beyond any reasonable doubt, that living forces are manifestations of a certain quantity of power to do work. The outcome of these studies and the publication of theories based upon them brought about a change, in Germany especially, in the opinions hitherto held as to the nature of the vital force or vital principle. Not a few were content to reduce life to a mechanical process and to deny any distinction between life and matter. Others sought to discover the life process and to make its development clearer by many different theories. The "potential energy" of Helmholtz, the cell formation theory of Schwann, set forth in 1839, and the theory of Max Verworn, of Jena, that life consists in the "metabolism of proteids" do not require the supposition of any principle or force apart from matter itself to account for life in any of the forms in which it has appeared. And yet these theories do not deny the possibility of the existence of a life principle. Neither does acceptance of the "physiological unit," as suggested by Mr. Herbert Spencer, prevent us from believing that life may be something quite different from this unit and independent of it even if it manifest itself in and through it. Accurately as these life processes, as they are termed, have been traced by the most capable experimenters in the world, the product of these experiments, however exactly it imitate that of nature differs from it *in toto*. The laboratory product may contain the same elements, and so far as can be seen, arranged in the same proportion, and yet be entirely unlike the product of nature. No chemist has yet learned how to arrange atoms of matter in a living organism and adapt that organism to an environment in any such way as to compete with nature or indeed to give to the product of the laboratory anything worthy of being called life.

Familiar as one may become with the processes of organization, science has not yet been able to develop life out of what appears to be dead matter. Nor has it yet been proved that life is ever spontaneously developed from dead matter. Something more than mechanical processes, or than the action of matter itself, is required for the production of life even in its simplest and most primitive form. It may come through the cell. The cell itself may be merely a bit of protoplasm. This protoplasm may be either a germ of life or of the body. One thing seems certain; life proceeds from life and is never produced by mechanical processes, however constant these may be after life has once appeared, or however necessary they may be after life has begun its career in matter.

As has been said, the study of biology is fascinating. It is likely to become more fascinating with renewed efforts to attack the problem of life in its secret fastnesses. There will always be some students of biology who will be content to assume the existence of life either as something which may reasonably be taken for granted, or as furnishing a problem which at present can not be solved. But there will be others who will feel that biology must remain an incomplete science so long as the origin and nature of life are unknown. Its study as yet is in the era of beginnings and, in spite of its apparently insoluble problems, is full of promise. For the problems of the science are interesting and worthy an attempted solution, even if it be found advisable to put aside all thought of a solution of the mystery of life itself.

The fourth of the concrete theories of the origin and nature of the universe is called by Merz the psychophysical theory. It presupposes the study of mind and matter as found in man, in their relation to one another. In this study we may proceed from within by introspection or speculatively, or we may proceed from without objectively, obtaining our knowledge of mind from what it does, as shown in history, science, art, language, as Herder suggested should be done.

In the study of mind introspectively, or as it reveals itself in connection with the human machine of which it makes constant and necessary use, such men have been prominent as Cabanis, G. T. Fechner, the leaders of the Naturphilosophie school of Germany, Schelling, Hegel and others, the Weber Brothers, of Leipzig, Du Bois Reymond, Herbart, the philosopher who rejected physiology altogether and insisted upon the study of the mind as a unit by itself, Thomas Young, as shown by his theory of colors, Charles Bell, who discovered the difference between the anterior and posterior roots of the nerves of the spine and did not a little toward pointing out the difference in their functions, and John Müller with his "specific energies" which have long been taken for granted in all physiological reasoning as to the nature of sense perception.

Helmholtz, too, has contributed not a little to the solution of the

problem as to the relation of body and mind in his works on hearing and seeing and on vision and music. Lotze, who has the credit of having banished the idea of vital force from the study of biology, has given especial attention to the study of the methods or rules of the psychophysical machine. But the most prominent and successful investigator in this special department of mental and physical study is Professor Wundt, of Leipzig. It is said of him that he combines in the methods he follows the truth found in Lotze's medical psychology and Helmholtz's physiology of hearing and seeing with valuable additions of his own. He approaches the study of mind from the side of physiology, but is careful to take into consideration the whole problem of mentality and thus avoid theories founded on the study of only a part of it. The older metaphysical psychologists explained "the unity and unified totality of all inner and mental phenomena" by assuming the existence of an independent entity, "the soul, the person, the self," at the beginning of their discussions. This modern psychology is unwilling to do. The unity of the inner life and its unified totality is a clearly defined problem. This problem Professor Wundt has sought to solve. The question he puts to himself is, "Wherein consists the unity of consciousness, wherein is the totality of all mental life, individual and collective?" It will thus be seen that he and his school are leaving no difficulty untouched, and if the results of their studies are not universally accepted as satisfactory it will not be from any lack of thoroughness on the part of those who have made them.

Objectively, the study of mind psychophysically may be made a basis for the study of language. Or from the study of language one may form some opinion as to the nature and origin of mind. The problems of language are many and difficult of solution. How did language originate? How has it been developed? What does its use indicate? Broca in 1861 located the organ of speech in the center of the brain and by his writings laid the foundation of the science of phonetics, but was unable to overcome the well-nigh universal conviction that we can not account for the beginning of speech or of its development upon a merely mechanical and material basis. Speech implies thought, and thought has not been proved to be an attribute of matter or a product of mechanics. Wundt has not failed to study the problem of mental life objectively as well as introspectively. He has created the science of psychophysics. He has originated the theory of the parallelism of physical and psychophysical phenomena. As easily the first in this department of study, it is to his laboratory and to the men he has trained that students who are awaiting the solution of the difficulties connected with the psychophysical problem are turning for light. Wundt uses the word epiphenomena, which may be discontinuous, even if life itself is continuous, to explain various mental manifestations. But even here in the effort to explain centralization

and externalization, or the expansion and growth of mind, it would seem almost as if the existence of mind were assumed. At any rate, its existence is not absolutely denied or made identical with matter.

There are scientists who think of mind as they think of matter, and therefore study its operations as if it were the product of physical forces alone. They are not surprised at the conclusions of Cabanis that thought is a product of the brain as organized matter. These conclusions seem to them the logical outcome of Locke's theory of knowledge and of the philosophy taught by the Frenchmen Abbé Condillac and Helvetius. To them there seems to be no good reason why phrenology should not be able to locate the different powers of the brain, as Gall and Spurzheim tried to do at the beginning of the last century, even if no attempt were made to account for the existence of that something called mind which makes use of the brain.

However close we admit the relations to be between mind and matter, however fully we may believe in the influence of the physical upon the mental machine in man, it is well-nigh impossible to escape the conviction that mind and matter are diverse in their nature, that even if mind makes use of matter in its operations and is aided by it so that mind and matter may properly be studied together as a new science, they are not thereby made one and the same thing. There are many who still look upon physiology and psychology as different sciences, and while recognizing their close relationship and welcoming the results of studies and experiments in the border land between the two, they still feel as if there were a science of mind which demands other experiments and studies than those which physiology is able to furnish. Nevertheless, it is certain that in all future studies of mental philosophy the physical nature of man will be taken into account.

From this brief review of theories concerning the universe, its origin and meaning, each of which has been prominent in its turn, each of which indicates a different point of view on the part of its defenders, and each of which has in it a great deal of truth, it is clear that no one of them can now be accepted as completely satisfactory or as covering all the problems which meet us in trying to explain the universe. Taken together, they disclose and give a reason for many of the processes of nature, but they do not explain them all. Indeed, with every new discovery new vistas open, new questions arise, new difficulties are to be met. We may, therefore, content ourselves by accepting that as true which is proved to be true by all the theories. The fact of gravitation is undeniable, even if the astronomical theory is no longer received as adequate. Although no one has ever yet seen an atom, sound reasoning seems to require us to admit the existence of atoms and justifies us in appealing to mathematics to prescribe the laws of an atomic world. Nor can we deny the evidences of universal motion, or that the kinetic theory has a good basis upon which to stand. Equally evident is it

that force, or energy, energy that can be measured, harnessed, made to do work, exists in matter, and that no satisfactory account of nature can be given which overlooks or neglects it. In these abstract theories we proceed from small beginnings and build up our theories upon conclusions which seem to be true. The great names connected with them are Newton, Lagrange, Fresnel and Helmholtz. In the concrete theories objects are found ready made. We take them as they are and seek to describe them, and give a reason for their distribution and for their existence. Hence the theory which occupies itself with forms, or the morphological theory. Nor is it less a matter of interest to know how these forms have originated, out of what materials and under what conditions. Hence the genetic theory, which is supported by an array of names the scientific world delights to honor. With the study of biology, or life, it is natural that there should be a vitalistic theory, and that in process of time the student should discover a border land between mind and matter subject in part to physical, in part to mental laws. So we have the psychophysical theory of the universe, and the deep and growing interest in the study of its problems. Yet however true each of these theories is, and there is truth in them all, it is certain that as science enlarges her borders, opens new fields of knowledge, these theories will be given up, or be modified to such an extent as to be virtually new, that the study of nature and her processes will continue to the end of time and that whatever advantages the man of science may have one thousand or ten thousand years hence, the problems then demanding solution will be neither less numerous nor less difficult than those which confront him to-day.

Yet these studies are of great value, not only for the practical benefit they bring to the world, but for the influence they have on those who pursue them. They teach men to be tolerant, for the fields to be traversed are so wide, the subjects considered are so varied and complex, and are cultivated with such diverse aims, that one can not be surprised at the different conclusions to which investigators, equally in earnest and equally competent, arrive. In a scientific mind dogmatism has no place. Love for old truth does not prevent hospitality toward that which seems to be new. Scientific studies are fitted by their very nature to produce enlargement of mind, clearness of vision and devotion to the search after truth. The man of science is not only far better prepared for his studies to-day by the mental attitude he is compelled to assume in beginning his special work than ever before; the equipment at his disposal is more complete and better adapted to his wants than his predecessors have enjoyed. Indeed, he is in this respect the heir of all the ages. It is his own fault if he is irreverent toward old truth, inhospitable toward that which is new, or lacking in devotion to search after that truth with which nature is full and is waiting to reveal.

COLD STORAGE PROBLEMS

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COLD storage is but one of many methods of conserving foods. There is a period of plenty for every food substance, during which time much would go to waste if there were no provision for conservation, and when prices are low to the consumer and profits large to the producer. During the balance of the year food is scarce and must of necessity bring exorbitant prices, if within reach at all. Usually the period of plenty covers but a fraction of the year and bears to some extent a definite relation to climatic and soil conditions. The gap between the periods of plenty and scarcity is felt least in the centers of population, where transportation facilities make many foods available throughout the year. There, for instance, berries are obtainable before and after the natural period of supply has expired, the provisions being carried in refrigerator cars from southern and northern climates, where conditions favor their production. Also many fruits, such as oranges, grapefruit and pineapple, are carried successfully from tropic and subtropic countries to parts of the world where they can not be grown. These conditions are made possible by efficient transportation. Undoubtedly within the near future transportation facilities will be improved so as to encourage the raising of crops in tropical climates to such an extent that fruits and vegetables will be available in northern countries throughout the year. Many luxuries of the table could not now be obtained, were it not for the systematic conservation of food articles.

There are more than 3,000 million dollars worth of foods placed in cold storage annually, of which about one half is meat. Capitalists are expending money and scientists are giving their time to the exploitation of this promising field. Although the problem is still in its infancy, ways and means of furthering cold storage are being investigated. The chief problems to be investigated are the handling of foods previous to placing them in cold storage; the chemical changes taking place during storage; the study of the microorganisms that produce these changes; the sanitary conditions of cold storage warehouses, and the care of foods after leaving cold storage.

Many foods that constitute a regular and almost necessary part of the diet of civilized man are really nothing but the results of preserv-

ing perishable products. As milk, for instance, perishes within a short time, the nutritive constituents have been transformed for ages into cheese, butter, fermented beverages, etc. During recent years milk and eggs have been evaporated or desiccated. Their keeping qualities are thus enhanced and by adding the requisite amount of water they can be restored to nearly their original condition. Frozen milk, which, when thawed, represents milk almost equal to the fresh product, is being exported from Denmark in large amounts.

In a crude and empirical fashion many substances have been subjected to preserving agencies for ages. Savages have desiccated meat, or preserved it by immersion in sour milk. The farmer slaughters in the fall and keeps the meat in his cellar, where low temperature and the drying out of the outer layer protect the meat from serious decomposition. Fresh fodder for cattle is fermented into silage and grapes into wine. Acids for pickling vegetables, fruit and meat; sugar in concentrated solution for preserving berries and fruit; these means have long been utilized. High and low temperatures also have been used extensively for preservation with success. These methods have been reduced by science to certain fundamental principles, which may be considered conveniently under five heads: (1) Harmless preservatives. (2) Chemical preservatives. (3) Heat. (4) Desiccation. (5) Low temperatures.

These methods to prevent "spoiling" of foods were practised to some extent before the causes of food decomposition were understood. With the dawn of the science of bacteriology it was learned that decomposition of organic matter was due almost exclusively to the vital activities of microorganisms. It became clear that the sole end was the destruction or restraint of development of these minute organisms. Microorganisms require food, but this food must be diluted with water, consequently the abstraction of water by desiccation or freezing, or by boiling in concentrated sugar solutions will restrain their multiplication. Some chemicals are poisonous to bacteria, but are used only to a limited extent on account of possible injury to the consumer. High temperature kills microorganisms rapidly, low temperature slowly, and below the freezing point there is little, if any, multiplication. It must be distinctly understood that in the absence of microorganisms many years must elapse before organic matter can show any signs of decomposition. If this fact is borne in mind it will readily be understood that, if microorganisms are restrained from activity or destroyed, no matter by what means, there can be but little change in food substances. Antidiluvian animals have been disinterred from a bed of ice, where they were buried for ages, and the flesh has been found to be still in good condition.

The chief object of this article is the consideration of effects of low

temperatures; the other methods will therefore be mentioned but briefly.

The Use of Harmless Preservatives

Sugar and acids are perhaps the most important of these. By adding large amounts of sugar to perishable foods, such as berries or their expressed juice, and dissolving the sugar by heat, the berries may be kept in good condition for unlimited periods. The same result is obtained by the use of acids in the preparation of pickled vegetables, pickled meat, the curing of hams, etc. Spices also act as preservatives and many delicacies are preserved in oil.

The Use of Chemical Preservatives

Of these benzoate of soda, formalin, boric acid and salicylic acid are used to some extent. Whether these are unwholesome in the small quantities used is still disputed. The relative amounts are certainly very small and harmful results can only be incurred by continued use. Alcohol is also a powerful preservative and is produced by allowing fruits, etc., to ferment. The perishable grape is thus transformed into stable wine.

The Application of Heat

The enormous canning industry uses heat as a preservative, followed by exclusion of air. First the microorganisms are destroyed by heat and then renewed invasion is prevented by sealing the containers hermetically. Temperatures, lower than those used for canning, are applied in pasteurizing milk and beer. Pasteurization is carried out by heating milk or beer from 140 to 145° F. for 20 to 30 minutes. This process does not kill all microorganisms, but the great majority, including disease germs. If pasteurized milk is cooled rapidly and kept cold it will remain sweet for days. Pasteurized beer will keep much longer, since the amount of alcohol contained in it aids in protecting against decomposition.

Conservation by Desiccation

Desiccation—the abstraction of water—has been applied to the preservation of fruits, meat, eggs and milk. Fruits are dried in the open air exposed to the sun or by artificial heat. Desiccated products, of course, can be of no better quality than the original substance. Poor fruit, dirty milk, decomposed meat and aged eggs can not be expected to improve by desiccation. Milk should be clean before desiccation, but unfortunately this is not often the case, and the production of eggs is not as sanitary and well regulated as might be desired. Eggs are rarely, if ever, sterile when freshly laid, the term sterile applying to the total absence of microorganisms. It is certain that, after laying, bacteria

can penetrate the shell, especially if the shell is moist. These bacteria find excellent food in eggs and will multiply at an enormous rate unless the eggs are kept cold. The producer usually brings the eggs once a week to the country store, where they remain for another week or two before being delivered to a factory for desiccation. When we consider that one bacterium may have a progeny of 17 millions in 24 hours under favorable food and temperature conditions, it is not surprising to find that eggs used for desiccation contain millions of microorganisms. Bad eggs are usually recognized by holding them up to a bright light in a dark room, a process known as "candling." This will reveal dark spots resulting from bacterial multiplication, or colonies of molds, or embryonic development of the chick. But we must remember that millions of bacteria take up a smaller space than the head of a pin, so that the process of candling will show their presence only after enormous multiplication has taken place. On the other hand, if fresh eggs are desiccated within a few hours or a day after laying and have been kept cold during this interval, the final product will contain about the same number of bacteria as the original eggs. It must not be assumed, however, that the presence of many millions of bacteria is necessarily injurious to health. Of all species of bacteria known to science an exceedingly small number is injurious, and these are rarely found in eggs.

Conservation by Cold Storage

The present methods of cold storage are the natural result of evolution from the practise of using the cellars of farmers and produce dealers. Surplus food material is stored in warehouses, where it will keep in good condition for various periods of time, these periods depending largely upon the degree of temperature maintained. Such storage makes possible an artificial season, which may be long enough to bridge the gap between one producing season and the next. The importance of this can not be overestimated and has found expression in the fact that the Canadian government is subsidizing cold-storage plants.

The degree of temperature to which foods are exposed in cold storage varies according to the nature of the food. Fruits, vegetables and and shell eggs are permanently injured by freezing and are therefore kept just above the freezing point. If eggs are broken, the yolks and whites mixed and then frozen, they can be preserved for a long time. What has been said about desiccated eggs applies with equal force to frozen and cold storage eggs. If they are in good condition when placed in cold storage or when broken for freezing they will keep for a long time. Usually considerable deterioration takes place before they reach the packer. Especially is this true of summer eggs. April and May eggs, if placed in cold storage in good condition, are of better quality

than so-called fresh eggs during the summer months. The popular prejudice against cold storage eggs is not entirely unjustified, since eggs are sometimes stored after having become tainted. As a rule, they are well taken care of after they reach the packer, while the producer uses no precautions to preserve their original condition. It is probable, that there are more tainted eggs sold, that have never been in cold storage, than tainted cold storage eggs. Microorganisms multiply slowly, if at all, at the freezing point. Scientific investigations have not settled this point satisfactorily. Some bacteria may survive at very low temperatures, but freezing gradually kills most of them, as has been demonstrated by bacteriological studies of ice. It has been shown also that the number of bacteria in eggs in cold storage decreases constantly to a point where but few are left. Some observations are on record which seem to show that bacteria may multiply slowly near or below zero. This subject needs more thorough scientific investigation. However, it is safe to say that eggs placed in cold storage in good condition will remain practically unchanged for many months.

Meat, poultry and fish are stored in large quantities in the frozen condition. It is perhaps not generally known that cattle are most plentiful during the three months of late summer and early fall, although there is a limited supply during the remainder of the year. The packers buy all the cattle obtainable, slaughter it, supply the immediate demand and place the surplus in cold storage. When the season of plenty has expired they can draw on cold storage stock and keep the market supplied. Thus prices are kept more or less balanced during the entire year. This is of inestimable value. The prices remain within the limits of every one and a plentiful supply can be carried over from one season to the next without allowing any to go to waste. The meat inspection service carried on by the government is well organized. Every piece of meat handled by the packer has a definite record and consequently only fresh meat is placed in cold storage. It is authoritatively stated that federal or state inspection of eggs and fruits destined for cold storage would be welcomed by all reputable packing houses.

Packers usually have three warehouses, a different temperature prevailing in each one. The fresh meat is hung in the "chill room" at a temperature of 32° F. The temperature gradually rises to about 40° F. while the room is being filled with fresh warm meat. The next morning the temperature is down to 32° F. again. The meat is then removed to the "freezer." Here a temperature of — 9 to — 12° F. is maintained and the meat left for two to four days. It is now frozen throughout and is transferred to the cold storage room and kept here at 12 to 15° F. This temperature is low enough to keep meat in a frozen condition. Poultry and fish are treated in a similar fashion.

The handling of poultry for cold storage is not as well regulated as that of meat. A large amount of poultry is killed on the farm, instead of at the packing house. From the farm it may be shipped by two methods, the "wet" and the "dry." If shipped "wet," the poultry is packed in ice and the skin becomes wet and softened, so that bacteria can penetrate readily. If shipped in modern refrigerator cars, which are recharged with ice every day, the poultry remains "dry" and arrives at the cold storage warehouse in good condition. Poultry is frozen either with the entrails (undrawn poultry) or after the entrails have been removed (drawn poultry). Formerly it was thought that the presence of the entrails had an injurious effect upon the keeping qualities and in some places ordinances have been framed prohibiting the shipment of undrawn poultry. Recent investigations have shown conclusively that undrawn poultry keeps in better shape than poultry drawn in the ordinary fashion. The fundamental cause for the difference in keeping qualities of drawn and undrawn poultry is the presence of bacteria in large numbers in the entrails. In the ordinary process of drawing, of which there are different methods, the membranes of the body cavity can not escape injury and bacteria invade the muscles. The membrane remains intact if poultry is not drawn, or drawn carefully. For practical purposes it is no doubt preferable to allow the entrails to remain until the poultry is prepared for consumption. Recently poultry has been frozen in paraffined pasteboard boxes, which are delivered to the consumer in a sealed condition and with proper directions for thawing. Frozen poultry should be thawed slowly in a house refrigerator, which process requires about two days.

The handling of fish for cold storage is surrounded with difficulties. Fish is not part of our daily diet as meat is, but is consumed largely on one day of the week. The fisherman may have a large haul or a small haul. If large, there will be surplus to be disposed of. A number of fish are frozen together, forming cakes of about 20 pounds each. The cakes are piled up on top of each other in a cold storage warehouse. The ice hermetically seals the fish, but every well regulated cold storage warehouse has some provision for ventilation and the moving air takes up the evaporating ice from the free parts of the cakes containing the frozen fish. The heads become exposed and are recovered with ice by periodical sprinkling and dipping. This requires considerable attention on the part of the warehouse man, but if properly carried out will preserve fish for long periods. Thus waste is prevented and the market kept supplied.

Changes taking Place in Meat, Fish and Poultry in Cold Storage

The changes taking place in meat, poultry and fish during cold storage are both of physical and chemical nature. The physical changes are chiefly those which are due to freezing and thawing. More than one half of the muscle substance is water. When the temperature of water is lowered the volume is reduced, but below 39° F. increases again. Therefore, when the meat is chilled below 39° F. the water contained in the muscle cells filters through the cell membrane and fills the interstices between the layers of cells. Here it freezes when the meat is placed in freezer storage. Gradually the interstices are filled with crystals of ice and the cells are squeezed out of shape. If the meat is thawed the result will be different according to whether the thawing process is carried on slowly or rapidly. If slowly, the water will filter back into the cells and they will assume, nearly at least, their normal shape, and the meat will, to all outward appearance, look like fresh meat. If the meat is thawed rapidly, considerable juice will ooze out and the cells will never resume their normal condition. It is better, therefore, to thaw meat slowly.

Some of the water contained in the skin naturally evaporates during cold storage, so that the skin shrivels. To restore the natural appearance and replace the lost weight, frozen poultry is frequently soaked in hot water. This softens the skin and favors the invasion of bacteria. Poultry treated in this fashion will deteriorate rapidly and the practise should therefore be condemned. The physical changes described do not injure the general appearance, flavor and digestibility of the meat, some investigators claiming that both flavor and digestibility are favored.

Whatever *chemical* changes take place in meat, poultry and fish in cold storage are chiefly the result of the activity of microorganisms (bacteria and molds). Since, however, bacteria multiply slowly at the freezing point, and probably not at all in frozen meat, the changes are slight. At 32° to 40° some changes are noticeable after 15 days' storage. These changes are also slight and are restricted not only by the temperature, but also by the layer of dry meat forming on the outside, which makes it difficult for bacteria to penetrate the interior.

The fat is probably not attacked by bacteria, but undergoes a slow oxidation under the influence of light and the oxygen of the air. By this process the acidity of the fat increases, but the change is very slow, if the meat is kept frozen, and is not noticeable for months. It has also been claimed that there is some change in meat due to the action of ferments, which may be contained in the muscle cells. This process is called "autodigestion." There is, however, no reliable evidence of this; in fact, new investigations seem to show that bacteria are the only agen-

cies worthy of consideration in the decomposition of meat. Ferments, moreover, do not act at very low temperatures, although they are not destroyed and resume activity when meat is thawed.

Whether bacteria multiply at freezer temperature in liquid foods is problematical. It is well established that bacteria die gradually in ice so that after several months ice is practically sterile. Ice, however, offers little nourishment for bacteria, while meat contains plenty of food, which is available if water is present. Bacteria can not multiply in solid substances and therefore multiplication in frozen meat is impossible. It is reasonable to assume that bacteria will die in frozen meat as they do in ice. Conditions of frozen fish are quite similar to those of meat and poultry. A few investigations of this problem are available and, in substance, agree with the findings in frozen meat and poultry. The bacteriological aspect of cold storage meats is largely speculative and scientific investigations are much needed to throw light on the problems of cold storage.

In a general way the conclusions reached by those investigators who have worked on cold storage problems are that there is no appreciable difference in chemical composition between fresh meat and meat kept frozen for periods longer than two years. No progressive changes could be determined with precision. In regard to frozen poultry it has been stated that the changes in chickens in 24 hours at 65 to 75° F. are greater than in cold storage at 10° F. for 12 months. The changes taking place in cold storage for 12 months are comparable to storage in a house refrigerator for 5 days, or in the packer's chillroom at 32° F. for 15 days, this not being sufficient time to bring about the tenderness and flavor of so-called "ripened" meat. Most chickens bought in the market as fresh are of poorer quality than chickens frozen for 12 months, and are poorer than many kept in cold storage for 16 months.

The conclusion is inevitable that cold storage at 10° to 15° F. has no deteriorating effect on the condition of meats, poultry and fish for a period long enough to bridge over the time from one flush season to the next, that is to say, for about 12 months. The term "deterioration" is a vague one and is interpreted largely on the basis of individual opinion and taste. Some foods are not considered fit to eat unless they have "ripened," but the ripening process is nothing but a decomposition brought about by bacteria and molds. Cheeses of all kinds are permitted to ripen for various periods of time and the changes taking place during the ripening process are comparable from a chemical point of view to the so-called deterioration of meat. The most delicate and savory steaks are subjected to a ripening process, which consists in storing them for 30 to 60 days at a temperature of 32°–40° F. During this time the muscle fibers undergo changes, which render them more soluble and consequently more tender, palatable and digestible. This is

practically the same process as the ripening of cheese, with this distinction, that decomposition of cheese is allowed to go farther than decomposition of meat. It is also true, that the tastes of individuals differ largely. Game is usually considered best when decomposition has gone far beyond that of ripened meat, and when it has developed the so-called "gamey" flavor, which is the result of progressive decomposition. Putrid eggs are preferred to fresh eggs by the Chinese, and rancid butter to fresh butter in some tropic countries. Some cheeses are most palatable to many people when decomposition has gone so far as to produce decay. The cheese then contains considerable amounts of ammonia, a sure sign of advanced putrefaction. Virginia hams after two years' storage are considered at their best by connoisseurs.

It can readily be seen that it is difficult to establish a limit in a process and call it ripening, while the same process continued for some time would be called deterioration. All standards to-day are arbitrary in the light of our knowledge and the judgment of health officers is seriously taxed. It is obvious that it is largely a matter of opinion, and it is certain that much investigation, chiefly from a bacteriological point of view, is necessary before intelligent legislation can properly take care of cold storage. Recently a bill was introduced into the federal senate, which proposes to limit the time of cold storage of beef to 7 months; of pork and mutton to 4 months; of poultry, game, fish, eggs and butter to 3 months. By such limitation the very purpose of cold storage is defeated and, in the light of our knowledge of cold storage problems, entirely unjustified. Regulation of commercial cold storage should be attacked from two standpoints: (1) Cold storage warehouses should be subject to government inspection as to construction, ventilation, temperature and sanitary conditions. This inspection should also be extended to refrigerator cars. (2) All foods destined for cold storage should be inspected as meat is inspected at the present time.

Poultry should be placed in cold storage only when fresh and the killing should be done by the packer. It should be stored undrawn. Under a system of inspection there is no reasonable doubt but that food coming out of cold storage would be in as good condition as when going in. Legislation limiting cold storage is entirely out of place. It is true, that foods coming out of cold storage decompose more rapidly than fresh foods, not because—as has been suggested—fresh food is still "alive," but because the physical structure has been changed to some extent by freezing, rendering the food more accessible to bacterial invasion.

The cold storage warehouse is an all-important asset to modern economy, but the facilities are limited at present. It has been stated that in Greater New York about two million pounds of meat are kept in cold storage, while the weekly consumption of meat is 80 million

pounds. If a storm or some other calamity should prevent the shipment of fresh meat the cold storage supply would last but a short time and a meat famine would follow.

It seems clear that cold storage is a great boon to man at present and will be of greater value in the future. Not many years ago, before cold storage facilities were generally available, it was not an uncommon occurrence to buy tainted meat from recently slaughtered animals. The animals had to be killed in places where flies were common and the meat offered favorable breeding places for the pests. Modern sanitary slaughtering houses with the addition of cold storage facilities have conquered many evils of similar nature. The cold storage industry should receive the hearty support of the public and it should be the aim of legislators to protect legitimate cold storage by appropriate regulations. This can not be brought about until the great problems involved have been thoroughly investigated both from a scientific and commercial point of view.

THE WORLD'S MOST IMPORTANT CONSERVATION PROBLEM

By STEWART PATON, M.D.
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THE world's most important problem is the discovery of methods of conserving and increasing the brain power of mankind. If we are judged by our ignorant and reckless dissipation of energy of the most complicated organ, which the process of evolution brings to us as a priceless heritage, we are still in the infancy of the race. Life, movement and being depend upon the activity of the brain and nervous system, our superiority over the lower animals is the result of greater brain power, while our relative ranking as members of the human family is commonly rated by the amount of "brains" we possess. Individual success no less than national greatness is proportional to brain power. A victory in modern warfare is a sign of greater mental efficiency than was necessary among the soldiers a century ago, while the efforts to win success in peace have lined the roads leading to the mountain tops with a far larger number of those who are mortally wounded in spirit than ever fell on the field of battle.

One of Napoleon's greatest errors was his failure to become interested in Pestalozzi's scheme of national education on the ground that he had no time to trouble about the alphabet. The conqueror forgot that brains and not brawn rule the world. In the great struggle of modern civilization, success as well as life depends upon the functional capacity of the brain and nervous system. What will the lessons of history profit or the teachings of wise men avail if these organs are too weak to translate precept into action?

It is a mere truism to affirm that the ultimate destiny of our civilization will depend upon the degree of efficiency developed by the brains of the members of future generations; but the importance of self-evident truths is seldom appreciated. If human intelligence is measured by the interest we take in the problem of the greatest importance in determining the destiny of the race, what shall we say of our ignorance and lack of forethought with regard to the most vital of all human problems? Modern civilization is constantly increasing the strain on the most delicate organ in the human body, while but puny efforts are made to supply the opportunities for obtaining the information about the brain necessary to avert disaster from overwhelming the

human race. While speaking in hysterical tones of a possible shortage of the wheat crop, or expressing gloomy forebodings of the failure of the coal supply, we are blind to the fact that some day there may be a shortage of brain-power, a deficiency made evident by our failure to cope successfully with the emergencies created by an advancing and more complex civilization. Universities, and so-called higher institutions of learning, do but little to encourage any effort made in the direction of finding out the laws which condition the activities of the brain. In relative importance all other questions become mere trivial academic discussions. If the public does occasionally discuss these topics it is "as if it had been struck by sentimentality."

Each new crisis in civilization calls for the exercise of more intelligence. Instead of having our wits about us and discussing the ways and means of developing greater cerebral capacity, we talk glibly enough about the man behind the gun, but make no effort to increase his mental efficiency. Although the success of representative government depends upon the fact that the majority of voters should have sound minds in sound bodies, we are more interested in the framing of new statutes than in any attempt to promote the mental growth of the citizens. Over the entrance to the New York Public Library the following words are inscribed: "On the diffusion of education among the people rests the preservation of our free institutions." This affirmation is true only if we include in "education" those agencies which aim to protect the brains of the people from injury. The nineteenth century supplied indiscriminately countless opportunities for squandering brain energy, and it now becomes the duty of the twentieth to determine the speed limits and endurance tests to which the most delicately balanced organ in the human body may be subjected without imperiling individual or racial existence.

In order to increase the brain power of a nation steps should be taken to conserve that which exists. Any reform which has this end in view should begin by taking cognizance of all the facts directly related to the problems under discussion, and then efforts should be made to provide the means and opportunities for extending our knowledge of this subject. In the movement to conserve the national forests the schools of forestry are not only repositories for knowledge, but are centers for investigations; the sources for information that vitalize the whole movement. An organization based on similar principles must form the basis of successful attempts to conserve all of our national resources, rivers, harbors, coal, forests and brains. First, there is the immediate attack in which the present store of knowledge is catalogued and presented to the public in an assimilable form. The popularization of the scientific knowledge of the brain will be one of the duties of the National Committee for Mental Hygiene. Equally important is the

establishment of bases or centers for the consideration of plans for acquiring additional facts to be used in winning the future battles against ignorance; and it is to this second plan of campaign, the discussion of methods for acquiring information, that attention is to be briefly directed.

In order to understand the methods employed in the study of the brain and nervous system attention must be directed to certain fundamental laws which are applicable to all forms of living organisms. Life will continue to be a subject of increasing interest to mankind, and the values of all forms of knowledge will be estimated by the better understanding that they give us of vital phenomena. During his early development man's interest in biology was chiefly limited to interpreting the phenomena of more common occurrence in his own life history, and to-day we observe the same egoism in savage races. Gradually educated people have awakened to a realization of the fact that the vital phenomena of plant and animal life vary in degree but not in kind from those observed in the human species. As a result of a limited horizon and a centripetalizing thought process man was led to assume a place of unique grandeur in the universe for himself, and this anthropocentric point of view not only dominated but seriously interfered with the actual progress made in the study of the brain. The concepts of this false philosophical system unfortunately limited the study of the nervous system to the human subject, whose nervous system represents the most complicated series of organs in the animal series. But more unfortunate than the establishment of false standards by which man's relative importance in nature was measured was the consequent diversion of human interest from the consideration of problems of the most vital importance to humanity. This was one of the penalties paid for assuming that the human brain had definite and specific functions not represented in other animals. The egoism of mankind is reflected in our present superstitions and ignorant attitude in regard to the questions connected with the cure and prevention of insanity. Attempting to conceal our defects by clamorously referring to our position of splendid isolation in the universe, we have failed to plan a rational system of education, and have been content to try to drive all who applied across the intellectual tight rope without any effort being made to determine the capacity of the individual nervous system to maintain its equilibrium while under strain or to restore it if disturbed. The results of these sins of omission afford excellent examples of the practical cruelties to which humanity is, as Anatole France has said, so often subjected by the sickly sentimentality that periodically is a blight upon our intelligence. Physicians compelled by the exigencies of practise too often confined their studies of anatomy and physiology to the organs of the human individual and thus unconsciously sanctioned

the view that the functions of man's brain and nervous system were specifically different from those of the lower animals. After centuries of hopeless wandering in a labyrinth, investigators at last picked up the ariadnian thread that connects the behavior of the simplest organism with the complex mental life of man, and students have come to realize that in the simpler structure and more easily analyzed functions of ameba, jelly-fish, crab or fish, is to be found the key that will eventually open the book in which we may read intelligently concerning the most complex psychic manifestation.

This change in our point of view is not only of philosophic but of great practical value. The student of the brain is no longer a Sisyphus. Investigators now know that a fact discovered in relation to the nervous system of worm or jelly fish may unlock some of the secrets of the physiology of man's brain. The advance from the study of the simpler reactions of the lower organisms to those of the higher animals is made by easy stages, and the knowledge that the continuity of the chain is unbroken is a source of hope and inspiration. Already the nervous system has been deprived of the mysterious specific properties which once it was supposed to possess. Eminent physiologists tell us that it has only those properties which are found to be distinctively characteristic of protoplasm, the physical basis of life. The capacity for receiving stimuli coming from the external world, of transforming, transferring and storing these impressions is characteristic of living organisms. Plants have the power to pick up and transmit a stimulus. An example of this power is seen in the closure of the leaves of the sensitive plant after being touched. As far as is known, however, plants do not have a differentiated nervous system, but between the various cells of which they are composed there are countless connections probably forming paths for the conduction of impulses. These conditions are not unlike those found in embryos of the higher animals at the time when the movements of heart and body have already begun, but before nerves have developed.

The study of the lowest organisms teaches us that the conductions of nervous impulses occur independently of nerves. More recent studies have led investigators to believe that the nervous system does not in any sense create function, but is to be regarded merely as the great regulator, the transforming apparatus called into existence to assist in preserving the equilibrium of each living organism, amid a play of energies, light, heat, electric waves, etc. As long as the equilibrium is undisturbed we say that the body is in a state of rest, but let that balance be disturbed by any stimulus and a reaction takes place. In comparison with other animals, some of our sense preceptions are very limited as our end organs or receptors are only attuned to pick up waves of certain lengths. Other living organisms, as, for example, many insects,

have the capacity of picking up sound waves of a much higher pitch than those which impress our duller senses, while the greater acuity of vision of birds, the keener sense of smell of various animals, the delicacy of perception of fishes for changes in pressure, are facts that are too well known to need repetition. To a certain extent these great differences in sense perception are directly referable to peculiarities in structure. The same fundamental system of construction characterizes the nervous system of the entire animal kingdom. The structural unit is the nerve-cell and nerve-fiber. The greater the number of these cells and fibers the greater is the complexity of the nervous system. Some of the cells are designed to pick up and transfer to the distributing apparatus the stimuli for which the organs are attuned. In addition to the receiving apparatus there is the transformer and elaborator of the incoming impulses, and finally there is the discharging apparatus as represented by the organs of locomotion, speech and others, which express objectively the sum total of the animal's activities. Already science has taught us something about the nature of that mysterious nervous impulse upon which thought, action and life depend. In fact there is a similarity between the rhythmic character of the life processes and the rhythmic discharges of certain types of cells in a battery. Here, as in all other enquiries which concern the energies of living matter, we are led back to the study of the cell. The millions of cells composing our bodies have certain common characteristics. The central portions are probably the parts most immediately related to the production of energy, while the external layers govern the taking in or throwing off of substances by the cell. A theory in regard to the manner in which anesthetics act attributes an important rôle to this external layer, as the place where the actual physico-chemical changes take place that result in anesthesia. The effects depend to a certain extent upon the presence in this outer envelope of certain fat-like substances which, combining with the enhaled ether or chloroform, produce loss of consciousness. There are also reasons for believing that in this same external layer of the cell the nerve impulse is generated, depending upon changes akin in their manifestation and mode of origin to those giving rise to electrical disturbances. One of the greatest services yet rendered biology by physical chemistry is the presentation of the facts suggesting that the regulation of the production of nerve impulses is not dependent upon some vague mysterious vital force, but is probably comparable to those phenomena called by the chemists "reversible reactions." The mixture of two substances may be followed by a chemical reaction in which the two original substances are in part decomposed, forming new chemical compounds. At a certain point this reaction ceases, as an equilibrium has been established, and then only after the balance has again been disturbed is the decomposition completed or a

restitution of the original bodies brought about. Physical conditions alone determine the direction taken by these "reversible reactions." This phenomenon suggests a possible explanation of the changes taking place in nerve cells and the relation they bear to the production and regulation of the nerve impulse.

Within the past decade biologists have discovered many facts that throw considerable light on the relation that the nervous system bears to the growth of the organism, and they have also arrived at certain conclusions of great importance in regard to the manner in which nerve cells grow. Portions of living tissues, nerve as well as muscle, or the supporting elements of the body may be removed and grown outside of the animal. Photographs taken at short intervals of nerve cells placed in various artificial media which are kept at the body temperature show a remarkable series of changes. In a comparatively few hours these cells may actually be seen to throw out long processes resembling the embryonic nerves.

A limited space does not permit more than a passing reference to the advances made, and largely by American investigators in the study of animal behavior. These newer methods of study, says a distinguished English scientist, "contrast with the anecdotal method of the past generation almost as pronouncedly as do modern chemical methods with those of the medieval alchemists." Modern biology with the inspiration derived from the physical and chemical laboratory has already brought new life into the discussion of such old questions as that of variation and inheritance in living beings. To answer the question "What are the traits inherited by our nervous systems?" we must follow the paths mapped out by the new biology. The way of the statistician has been followed until the new road offered by experiment is within our sight.

Posterity will, as we have already indicated, measure our intelligence by the interest we take in acquiring information in regard to the organs upon the functional development of which depend our continued existence as a race. In the various medical schools and hospitals throughout the country the problems connected with the human brain and nervous system will continue to be subjects that have an immediate claim upon the attention of physicians, but even in these institutions these questions should not be forcibly disassociated from the consideration of more fundamental biological phenomena. The possibility of extending the scope of the work carried on in the biological departments of our universities so as to facilitate and encourage investigations in the broad field of biological psychology would be an important factor in bringing these institutions into the closest touch with the subjects of most vital importance to humanity. But in addition a new type of institution dedicated to the study of neuro-biology is greatly needed. The Phipps Psychiatric Clinic in Baltimore will mark a new era in this

country not only in the study of nervous and mental diseases, but also in advancing our knowledge of many questions of immediate importance for educators and those interested in the solution of social problems. The way has been prepared by science for the establishment of a new type of institution dedicated to the study of the brain and nervous system along broad biological lines. This field of investigation would include, for example, such problems as an enquiry into the nature of the nerve impulse, the manner in which it is transmitted, the changes produced by it in the body, the agents modifying its action, the factors determining the growth of the nervous system and the possibility of inducing regeneration, after the nerve cells and fibers have been injured, and the mechanism of transmission by heredity of specific functions of the brain. The neuro-biological institute should contain laboratories fully equipped for the study of complex chemical and physical problems, the determination of the laws of animal behavior, the mechanism of development of the nervous system as well as the character of structure of these organs. The selection of investigators should be made with care and the greatest amount of liberty given to them in selecting and determining the scope of their own problems, for in attempting to answer the questions of fundamental importance in connection with the brain and nervous system we are brought face to face with a line of work which leads us straight back to consider the origin of the life processes.

The advance of humanity during the past fifty years has been illuminated by the acts of an intelligent philanthropy. The noble list of benefactions includes libraries, schools, colleges, universities, laboratories, observatories, hospitals and an international tribunal for the abolishment of wars. The future progress of mankind will be directly proportional to the additions made to our knowledge of the brain and nervous system. Whether the conventional form of education proves to be a blessing or a curse will depend upon its power to minister to the needs of brain and nervous system. The reign of universal peace will come at last, not as an official act of international agreement, but as the result of the study of the individual and the adoption of methods to suppress and eliminate those undesirable mental traits which at times make the resort to arbitration impossible.

Far more important than the discovery of a new continent or a new star is the determination of the laws governing brain action, for upon our knowledge of these phenomena depends "the prosperous voyaging of humanity."

TRINIDAD AND BERMUDEZ ASPHALTS AND THEIR USE IN HIGHWAY CONSTRUCTION. II

By CLIFFORD RICHARDSON, M. Am. Soc. C. E.

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The Bermudez Asphalt Deposit

From the mouth of the Orinoco, the northeastern coast of Venezuela, which faces Trinidad, is low and consists of vast mangrove swamps, through which run deep tidal estuaries. That portion forming part of the State of Bermudez extends inland for many miles. It lies on the opposite side of the Gulf of Paria from Trinidad. About 30 miles in an air line from the coast the asphalt deposit, known as the Bermudez pitch lake, is found at the point where a northern range of foothills comes down to the swamp. The Guanaco River, a branch of the San Juan, one of the large caños or estuaries of this region, at about sixty-five miles, in its winding course, from its mouth, runs within three miles of the deposit, but it is five or six miles to a suitable wharfage site. On the other hand, towards the north, a road runs to the hills and to the village of Guaryquen. These are the means of communication with the deposit. The so-called lake is situated between the edge of the swamp and the foothills in what might be termed a savanna. It is an irregular-shaped surface with a width of about a mile and a half from north to south and about a mile east and west. Its area is a little more than 900 acres, and it is covered with vegetation, high rank grass and shrubs, one to eight feet high, with groves of large moriche palms, called morichales. One sees no dark expanse of pitch on approaching it as at the Trinidad pitch lake, and except at certain points where soft pitch is welling up, nothing of the kind can be found. The level of the surface of the deposit does not vary more than two feet and is largely the same as that of the surrounding swamps. In the rainy season it is mostly flooded and at all times very wet, so that any excavation will fill up with water. These conditions make it difficult to get about upon it or to excavate pitch easily.

It is readily seen that this deposit is a very different one from that in the pitch lake of Trinidad. It seems to be in fact merely an overflow of soft pitch from several springs, over this large expanse of savanna, and one which has not the depth or uniformity of that at Trinidad.

At different points there is at most a depth of 7 feet of material,

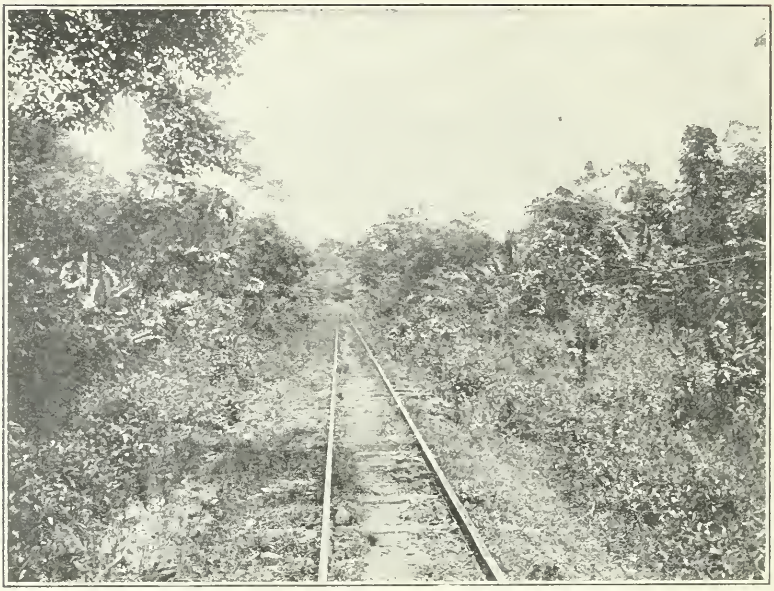
Photo, W. H. Rau, Philadelphia.

Bermudez Pitch Lake, Venezuela.

while the deepest part of the soft maltha is only 9 feet and the average of pitch below the soil and coke only 4 feet. At points there is not more that 2 feet of pitch, and in the morichales or palm groves it is often 5 feet below the surface. At several points scattered over the surface are areas of soft pitch, or pitch that is just exuding from springs. The largest area is about 7 acres in extent and of irregular shape. This has little or no vegetation upon it, and from the constant evolution of fresh pitch is somewhat raised above the level of the rest of the deposit. This soft asphalt has become hardened at the edges, but when exposed to the sun is too soft to walk upon. The material is of the nature of a maltha and it is evidently the source of all the asphalt in the lake, from these exudations the pitch having spread in every direction, so that no great depth of pitch is found even at this point.

A careful examination of the surroundings shows that in one respect there is a resemblance between the point of evolution of the soft pitch at the Bermudez and at the Trinidad lakes. Gas is given off in considerable quantities at both places, and in both cases consists, partly, at least, of hydrogen sulphide.

The consistency of the soft pitch at the center of the Bermudez lake is much thinner than that of the Trinidad lake. It will run like a heavy tar and does not evolve gas in the same rapid way or harden as quickly after collection. It therefore does not retain the gas which is generated in it, nor does the deposit as a whole do so to the same extent as the Trinidad pitch.



Photo, W. H. Rau, Philadelphia.

Railway from Bermudez Lake to Wharf at Guanaco.

The general surface of the lake is very irregular and hard. There are many very narrow and irregular channels or depressions from a few inches to four feet deep, filled with water, and, not being easily distinguished, one often falls into them. At the foot of the growth of grass and shrubs are ridges of pitch mingled with soil and decayed vegetation, which have been plainly coked and hardened by fires originating in the surface growth. When this hardened material which forms only a crust is removed, asphalt of a kind suitable for paving is found. The crust is from a foot and a half to two feet in depth and very firm, while the asphalt underneath would not begin to sustain the weight which that of the Trinidad pitch lake does easily. There are breaks in the crust here and there through which soft pitch exudes, as has been described.

It appears, therefore, that the Bermudez deposit owes its existence to the exudation of a large quantity of soft maltha, which is still going on and which has spread over a great area; that this has hardened spontaneously in the sun, and has also, by the action of fire, been converted over almost the entire surface into a cokey crust of some depth, beneath which the best material lies, and that here and there are scattered masses of glance pitch produced in a similar way from the less violent action of heat. There is no evidence of a general movement and mingling of the mass of this deposit in any way that would produce a uniformity of composition, as seen in the Trinidad pitch lake, although there is a certain amount of gas evolved at the soft spots where maltha

exudes and some gas cavities are found in the general mass of the pitch beneath the crust. As the asphalt below the crust of the deposit is the only portion of value for paving, the question has arisen as to its uniformity.

An examination of a series of samples collected in 1894 shows that the asphalt from the Bermudez deposit may vary very largely in the amount of water which it contains, from 11 to 46 per cent. None of it, however, is present in the form in which it occurs in Trinidad asphalt. It is not emulsified with the bitumen, but is all adventitious surface water. The percentage of oils which it volatilizes at about 400° F. varies from 16 to 6 per cent., consequently the consistency is far from uniform. The material carefully selected for use industrially is fairly constant in character, however, and when carefully refined has the following proximate composition:

THE COMPOSITION OF REFINED BERMUDEZ ASPHALT

Specific gravity, 77/77° F., orig. substance dry	1.082
Color of powder or streak	Black
Luster	Bright
Structure	Uniform
Fracture	Semi-conchoidal
Hardness—original substance—at 77° F.	Soft
Odor	Individually asphaltic

Photo, W. H. Rau, Philadelphia.

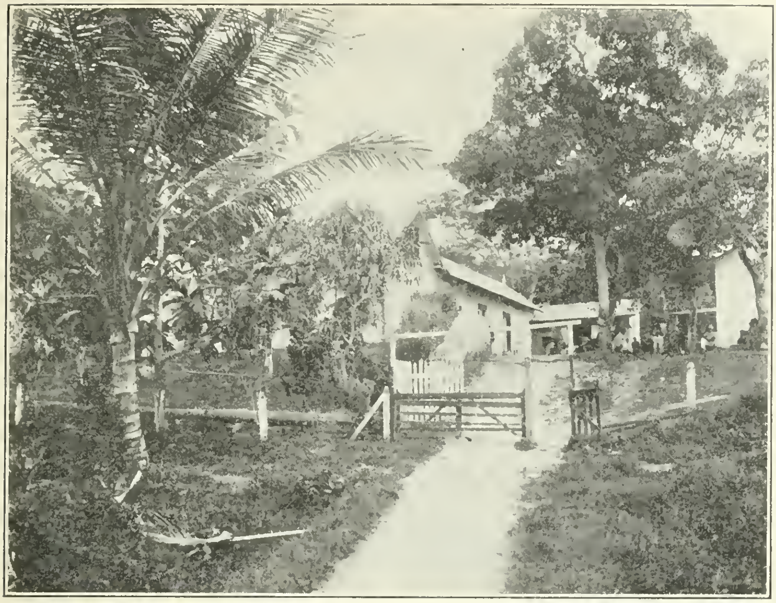
DUMP OF CRUDE BERMUDEZ ASPHALT AT GUANACO.

Flows (melting point N. Y. T. L. method)	151° F.
Penetration at 77° F., 5 sec., 100 grams, No. 2 needle	3.0 mm.
Loss 20 grams 325° F., 7 hours, 2¼″ dish	2.9 per cent.
Character of residue	Smooth
Penetration at 77° F., 5 sec., 100 grams, No. 2 needle	1.2 mm.
Loss 20 grams 400° F., 7 hours, 2¼″ dish	7.2 per cent.
Character of residue	Smooth
Penetration at 77° F., 5 sec., 100 grams, No. 2 needle	.4 mm.
Loss 50 grams at 325° F., 24 hours, 2⅞″×1¼″ dish ..	3.9 per cent.
Character of residue	Smooth
Penetration at 77° F., 5 sec., 100 grams, No. 2 needle	.5 mm.
Bitumen soluble in CS_2 air temperature (70° F.) ...	94.6 per cent.
Difference	1.5 per cent.
Inorganic or mineral matter	3.9 per cent.
	100 per cent.
Bitumen soluble 88° naphtha, air temperature (70° F.)	67.3 per cent.
This is per cent. of total bitumen	71.2 per cent.
Carbenes—per cent. bit. insol. CCl_4 air temp. (70° F.)	None
Bitumen yields on ignition: Residual coke	12.9 per cent.
Sulphur	5.5 per cent.

It appears from the above that the Bermudez asphalt is differentiated completely from that found in the Trinidad pitch lake, by the absence of

Photo, W. H. Rau, Philadelphia.

RAILWAY TERMINAL AT GUANACO, PIER IN DISTANCE.



Photo, W. H. Rau, Philadelphia.

RESIDENCE AT GUANACO.

emulsified water and mineral matter. It is a much purer bitumen, a fact of no importance as far as its technical application in street paving is concerned, since the fine mineral matter or filler must be added to any asphalt cement in its use in such construction, but which is of advantage where the material is to be used in the construction of bituminous broken stone highways by the penetration process, owing to the greater ease with which the purer and more liquid material will enter into the voids of the broken stone.

The ultimate composition of the pure bitumen of Bermudez asphalt is much the same as that of the bitumen in Trinidad asphalt, as can be seen from the following comparison:

	Bermudez Pure Bitumen Per Cent.	Trinidad Pure Bitumen Per Cent.
Carbon	82.88	82.33
Hydrogen	10.79	10.69
Sulphur	5.87	6.16
Nitrogen	.75	.81
	100.29	99.99

Bermudez asphalt contains, like the Trinidad, a high percentage of sulphur, varying, however, according to the degree to which the material has become hardened at different points in the deposit. The softest material contains the largest percentage.

[1] Soft material, maltha.

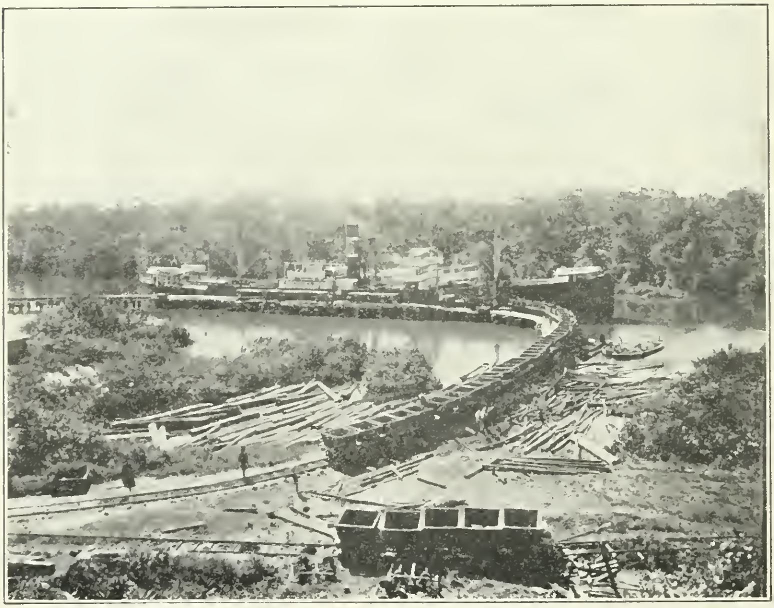
In this connection I would say that in a paper read before the New York Section of the Society of Chemical Industry in November, 1897, and published in the *Journal* of the Society for January, 1898, I stated that, in my opinion as the results of investigations extending over eleven years:

Asphalt is in process of formation to-day. It plainly does not originate as such but is a secondary product resulting from the transformation of suitable lighter forms of bitumen, malthas or even thinner oils into harder bitumen by condensation and polymerization. A reaction in which sulphur, and probably sulphates seem to take an important part.

This conclusion was based on the fact that an ultimate analysis of the pure bitumen from fourteen solid asphalts from various parts of the world, showed the presence of from 9.76 to 4.78 per cent. of sulphur, while in the softer forms of bitumen which rapidly harden on exposure to the atmosphere, or on heating, notable amounts of sulphur, 2.0 per cent. or over are found.

The same conclusion seems to have been arrived at, independently and apparently without a knowledge of my investigations, by Dr. D. Holde, of the Royal Testing Laboratory near Berlin. In his book on mineral oils and fats he says:

A bitumen would be called native asphalt when it contains considerable amounts (2–10 per cent., usually over 4 per cent.) of sulphur not removable by



Photo, W. H. Rau, Philadelphia.

PIER AT GUANACO.

Photo, W. H. Rau, Philadelphia.

Guanaco River as Viewed from Pier.

steam, when the amount of the latter in the chloroform extract which is insoluble in benzol is at least 7.5 per cent. and the asphalt, separated according to the method of Marcusson and Erckmann, contains 1.4–3.1 per cent. of oil with at the most 0.6 per cent. paraffin.

A bitumen would be called a petroleum residual pitch if it contains at most 1.7 per cent. of sulphur, even in the chloroform extract prepared as previously described and further 26–59 per cent. of oil in which the paraffin amounted to 3.3–16.6 per cent.

These conclusions of Holde are confirmed by my own data given in the paper to which I have referred, and are of the greater value on that account.

It appears, therefore, that a native solid asphalt is characterized by the fact that it contains sulphur, and the same thing is true, though in a lesser degree, of the softer bitumens from which it is derived.

Aside from the mere fact that sulphur is present in asphalt it is undoubtedly true that some of the most important physical characteristics of the material and those which distinguish it from the residual pitches are due to its presence, that is to say, the greater lack of susceptibility to change in consistency with change of temperature in the solid asphalts than is the case of the residual oils and pitches.

It is the presence of such a large amount of sulphur derivatives in Trinidad and Bermudez asphalt which makes them so desirable for use in highway construction, as compared with the residual pitches pre-

pared from petroleum oil, which contains practically no sulphur derivatives.

In proximate composition Bermudez is very similar, as far as the bitumen is concerned, to that of the Trinidad material. The proportion of malthenes is slightly larger, and the asphalt in consequence somewhat softer, but in general, it is of a very similar character.

Shipping the Asphalt

As will be seen in the accompanying illustrations, the crude asphalt is won from the surface of the pitch lake by laborers with picks, in the form of flakes which have been mentioned. Those are thrown into

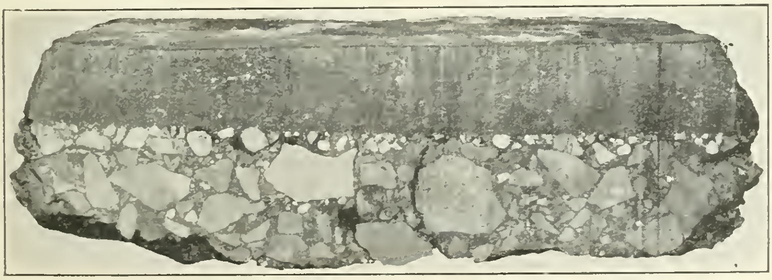
Photo, W. H. Rau, Philadelphia.

Guanaco River, Venezuela.

skips carried on small platform cars, which are run over the surface of the lake in a loop by cable, the rails being supported by palm-tree ties. which must be realigned almost daily, owing to the movement of the surface of the pitch. The loaded skips are brought to the terminal station at the shore of the lake, where they are hoisted and dumped into other skips, which are carried on a cable-way down the surface of the country between the lake and the shore, and out into the ocean on a pier some thousand feet in length, where they are emptied into chutes and dumped into the hold of the vessel awaiting a cargo. A thousand tons or more can be put on board a large steamer in this way in a day. During a large part of the year, three to nine vessels a day are lying off of or alongside the pier, waiting to be loaded.

TRINIDAD LAKE ASPHALT PAVEMENT, WASHINGTON, D. C., VERMONT AVENUE,—
ARLINGTON HOTEL. Laid in 1878.

Much the same process is carried out at the Bermudez deposit, but the asphalt is carried from the lake to the shore of the river on a railway instead of by cableway. In either case, the crude material having been dumped into the hold of the vessel, runs together into a compact mass during the voyage to the United States. In consequence, it must be again picked out by laborers as it lies alongside the pier, and loaded into skips in which it is raised and again dumped into others, which are carried by a small railway to large storage bins holding several thousand tons, where it is again hoisted and dumped for storage until it is refined. Of course, in these bins it again runs together into a solid mass. As a supply is needed for refining, it is picked out and transferred to large rectangular tanks holding a hundred tons each, which are provided with gangs of pipe carrying steam at a pressure of 125 pounds and of about 325° F. This heat removes the water and melts the pitch.



SECTION OF VERMONT AVENUE PAVEMENT.

Agitation is provided by passing some of the live steam through the crude material while it is heating. When there is no further evolution of steam and the melted mass has become tranquil, it is drawn off from the bottom of the tanks into open cement barrels placed on flat cars. These are not filled at once, but are topped off after the first filling has cooled, so that there shall be no loss of material. The product obtained in this way is the refined asphalt of commerce, and is in shape for shipment to whatever point there may be demand for it.

It may be interesting to note that the amount of crude material shipped from Trinidad during recent years, has reached as high as 180,-

Fifth Avenue at 34th St., New York City. Paved with Trinidad Asphalt 1897, photographed 1911.

000 tons per year, while that from the Bermudez deposits has reached as high as 47,000 tons but is rapidly increasing. The entire amount shipped from Trinidad since 1867 has reached three million tons, which would be equivalent to 180 million square yards of sheet asphalt pavement.

Service Tests of Trinidad Asphalt

Trinidad asphalt being for many years the only available supply of such material, it was the only one used in the early days of asphaltic highway construction in the United States. It has been subjected to the most varied environment with the most satisfactory results. There are in existence to-day three pavements which are worthy of consideration, as showing its capacity to meet different kinds of traffic and different climatic conditions.

A sheet asphalt pavement was laid in 1879 of Trinidad asphalt, on Vermont Avenue in Washington, between H and I Streets. This pavement is still in existence, and during that period has cost only in the neighborhood of ten cents a square yard, for maintenance for the entire period. It is apparently good to-day for ten or fifteen years more. This street is one of very moderate travel, delivery wagons and pleasure vehicles, and being very broad, over 100 feet, this is well distributed The pavement is typical of what Trinidad asphalt will do under such conditions for a long period of time.

Another striking piece of Trinidad sheet asphalt pavement is that on Fifth Avenue in New York, between 10th and 59th Streets. This was laid under the personal direction of the writer in 1896 and 1897, and has

VICTORIA EMBANKMENT, LONDON. Paved with Trinidad Lake Asphalt in 1906.

withstood the very heavy travel which Fifth Avenue carried in a most satisfactory way for fifteen years, the number of vehicles passing any one point, when the travel is the greatest, being at the rate of as high as 14,000 in ten hours. No other smooth surface pavement in any country has withstood the conditions existing on Fifth Avenue with an equally satisfactory result.

The third type of Trinidad sheet asphalt pavement is that found on the Victoria-Thames Embankment in London, the first portion of which was put down by the writer in 1906, upon old macadam and a course of Trinidad asphalt concrete. Much the larger portion of the embankment has since that time been paved with this same form of construction, other forms having been removed in the meantime as unsatisfactory and replaced by it. The surface of the Embankment is rarely dry from November to April, and it carries the very large traffic which pro-

ceeds from Westminster to the city. This serves as a striking evidence of the ability of Trinidad asphalt to resist dampness and to carry heavy travel in such a climate and in such a city as London, without deterioration.

I may further illustrate the uses of Trinidad and Bermudez asphalt by citing bituminous broken stone surfaces which have been constructed with these asphalts in Massachusetts and in the State of New York, which have been in use for at least three years, and have given the greatest satisfaction, the most striking feature of these roads being that the bituminous binding material is not drawn to the surface by the hot summer sun, but remains in the road where it is placed, with the greatest stability. Surfaces of this kind have furnished the most satisfactory service tests which are at present available, of a bituminous broken stone construction.

AN ECONOMIC INTERPRETATION OF PRESENT POLITICS

By Professor C. C. Arbuthnot
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ONE hesitates in taking the reader's time to call his attention to the fact that the present is an exceptional period of political unrest and anxiety over governmental policies touching certain public economic relationships. "Conservation," "graft," "the tariff," and "special privileges" have been talked about and about until the honest citizen who is trying to get a decent living for his family would be utterly weary if he were not so vitally interested in the results of the agitation. His interest in insurgency has become a demand for progression. There is determination in it.

The conservatives have felt that the whole hubbub is the result of unreasonable clamor, cheap reformers and low-priced magazines; that the people do not know when to leave well-enough alone, and that the wise policy is to adhere to the time-honored practises of the fathers until the storm blows by. On the other hand, great masses of the people are smarting under a sense of wrong and burdened by a feeling of oppression too great to be borne. They suspect they are playing the game of life with the cards stacked so that neither skill nor luck can be hoped to yield results favorable to themselves. The popular demand is for "fairness," "a square deal," and "equality of opportunity." The uneasy feeling prevails that the general public is losing something as well as the sense of personal injury. An exploitation of the many, collectively and individually, for the benefit of a few seems to be the evil of the day. Passionate reproaches, fierce denunciations, and tempestuous outbursts of feeling accompanied by determined action are aimed at the abuses. And yet no one can point to any fresh overt acts, or new public policies, or unusual legislation against which to protest. The subjects of the complaints are not the uncommon features, but the complaints themselves are. The economic and political phenomena assailed are time-honored, well-established heritages from the country's past that have come down to us from far enough back to be esteemed almost institutions characteristic of the republic. They do not need to be explained. It is the outcry against them that is to be accounted for, and the understanding is not far to seek. It is evident in view of our economic history.

Careful readers of history and students of social movements have

never seen the man on horseback appear in contented eras among satisfied people, notwithstanding all there is to be said for the powers of persuasion, the stir of audacity, and the impact of personality. The ponderous body politic can not be moved by word of mouth nor by the breath of eloquence. Merely preaching to it is foolishness. Internal pangs or external irritation are required to arouse activity. Demagogues are symptoms, agitators are weather cocks, and reformers are men who put themselves at the head of processions. When conditions are favorable for the start the opportunity for leadership arises and the self-seeking struggle with the public-spirited for the direction of the aroused energies. This guidance is of immense importance and no one should shut an eye to the danger of the glory-hunter's sway, nor lessen the credit due the reformer. But to understand the social situation in times of agitation there is need of separating in mind the more or less factitious elements from the fundamental forces at work. From this point of view speeches in legislative halls, on the stump, from the platform and the pulpit, the declarations of political parties and the editorials in the press, the harangues of public-square orators and the excited utterances of disputing citizens are not in the last analysis the outcome of the personal desire of a man or of a group, nor of a spontaneous moral tidal wave sweeping the community, nor of a resolute tugging at the ethical boot-straps of the country. Great national movements are products of fundamental forces in national life. The prophet who lifts his voice before these forces have begun to work dies in disappointment, or, if his message is too unpleasant to his contemporaries, he may achieve martyrdom. And if he has seen truly, succeeding generations may canonize him. The current of a people's thinking is glacial, slow to move; irresistible but largely determined by the contour of its bed. To the study of this formative influence one should address himself for an understanding of the greater changes that mark the history of public opinion.

At the close of the eighteenth century this nation began its career under unique conditions. A relatively small number of people possessed a vast territory over part of which they were sparsely living. Natural resources were boundless and wealth to be had for the taking. Acquisition was the watchword of the time. To open up the country was the economic ideal of the period. To this end were turned by common consent all the individual and collective energies available.

Among the most pressing needs of that day was that of capital for fixed investment in such improvements as better means of transportation. This was difficult to secure because the people were without great accumulations of wealth or the experience and instruments for readily collecting what was in existence. The machinery now in operation for promoting great enterprises and carrying through speculative ventures

is modern. If the Americans of the first years of the nineteenth century could have called forth an institution like the present Wall Street they would have regarded it as the greatest of blessings. As it was, one of the great accumulating agencies was the national government through its taxing power, especially in the form of customs duties. Besides and resting upon this was the public credit made strong by a ready and vigorous policy of paying public debts. The commonwealths shared this credit in a reflected form because leaders did not discriminate sharply between bonds of the states and obligations of the nation. Under such conditions of need for capital to develop the country economically and to bind it together politically, with an agency for supplying the want subject to popular will, it was inevitable that the people look to the government for aid in the construction of the desired public improvements.

Another resource of well-nigh unlimited extent lay in the hand of the federal government. When the British Crown granted charters to many of the colonies that later became parts of the original union, there was no exact knowledge of the lay of the land or the size of the interior of the continent. The terms of the grants were incompatible. The territories given overspread each other so that a division of the land among the independent states which came out of the revolutionary struggle was impossible. The problem was solved by turning over to the national government practically the whole of the area in question. The nation found itself in possession of a domain imperial in scope and possibilities.

With public credit and public land subject to the control of a people full of energy and ambition there could be but one result; their use with a lavish hand in furthering the interests of those who were developing the country's resources. Constitutional provisions, the reflection of current theory, limited the functions of government and we evolved a one-sided individualism whose chief tenet was state control in public benefactions to subjects and *laissez faire* in private use and enjoyment. Every citizen became an actual or potential beneficiary in the distribution of land and the extension of credit. The easy terms of the land laws threw open the widest opportunity for the acquisition of a farm to any one who cared to take it.

In order to bring these lands within range of the markets good transportation was necessary. The failure of the schemes for this purpose in most of the states in the thirties left a free field to corporate enterprise and every effort was made to encourage the construction of the means of carriage by private companies. The federal government gave lands to the states to be passed on to the railroad organizations as a stimulus. Other lands were given direct. The national credit was granted to new enterprises and second-mortgage bonds taken as security. Immense amounts

of wealth in lands, money and other forms were granted by smaller political units. This lavish generosity upon the part of governments had the warm support of the whole body of the people because the greater number of the individuals in the country were directly sharing in it or expected further indirect benefits from the development that would follow easy and cheap intercourse.

In this era of expansion the people thought in round numbers and on a grand scale. The superabundance of natural resources and the size of the anticipated results would have made any close scrutiny of the details of the transactions involved seem parsimonious cheeseparing, petty querulousness likely to interfere with the success of the transaction in hand and sure to delay the consummation unanimously wished. The popular will demanded that the thing be put through. All interests had to be conciliated and the ways greased if speed were to be attained. In thus doing business on wide margins and wholesale practically every one who helped the scheme forward felt a democratic right to participate in the benefits conferred. Legislators and administrators looked for an honorarium as a part of the exchange of courtesies incident to the negotiations connected with any public improvement of importance. The people at large were more interested in the execution of the proposed work than in the way it was carried out. Official parasitism on public improvements, graft, was regarded lightly as merely a sharing in the general distribution of the public largess. It was a commonplace; beneficial to the recipients and injurious to no one because, forsooth, it came out of the public abundance.

Development was the word to conjure with during most of our past and its magic opened men's minds to suggestion in every field of effort. Very early the creation of manufacturing industry became a desideratum. The infant industry needed protection. Notwithstanding the opposition of the South which then saw no promise of local benefit in the policy, the rest of the country enacted a tariff that took the edge off foreign competition if it did not entirely prevent it. Behind this barrier there came into existence factories and mills for the production of commodities as varied as the resources of the country would supply with raw material. The producers of this material rejoiced in the existence of a market immediately at hand and felt the benefit of the policy that the nation was more and more committing itself to carrying out. These new and flourishing manufactories were the nuclei of an urban population ready to purchase the products of farm and field: hence the agricultural interests were persuaded that the value of their lands was enhanced and their labor made profitable by the legislative act that brought the artisans and their families from Europe to the United States. Some palatable arguments allured many into thinking that the duties collected came from the foreigner, while others confident in the

strength of the expanding nation felt this was another of those beneficent acts of a government rich and solicitous for the well-being of all its citizens. The smoking stacks, the revolving wheels and the hum of the looms were referred to with pride as evidence of success in constructive legislation. As time went on faith in the possibility of legislating the country into prosperity continuously grew stronger and grants of protection became as common as grants of land. The favors were passed around by mutual consent and bargaining until customs duties were placed upon the importation of so many articles that precise knowledge of the effect of the whole system is beyond the grasp of even diligent students. The degree of industrial peace within our walls and prosperity in our palaces was commonly accepted evidence of the success of the American policy that silenced to most ears the doctrinaire objections of a discredited minority.

Parallel with national aid to industry were the grants and franchises given by local and municipal governments with a view to promoting public improvements within their jurisdictions. Street railways were essential to the development of towns and every inducement was offered to capital to lead it to go into their creation. The anticipated benefits were great, and the average citizen, who was busy trying to acquire his share of the collateral gains that were expected to accrue to the community, did not pay much attention to the terms of the contracts, while his representatives frequently exacted from the promoters of the new enterprises the customary informal fees to which in an era of acquisition they felt they were entitled. Fortunes were made all around them through the simple process of taking with governmental sanction and public approbation the lands, the bonds, the tariffs and the franchises that were to be had as part of the great scheme of continental development. There was nothing unusual in picking up these fragments when there were basketfuls being passed. The practise was common and hardly unclean.

From the conditions indicated in this brief analysis of our economic development it is easy to see how certain ideas came to prevail widely in the minds of Americans. At the bottom of our thinking has been the conception of a boundless productive continent to be parceled out by the government among its citizens. We have had the feeling that "the government" apart from the people as a body is wealthy. "Uncle Sam is rich enough to give us all a farm" is a popular expression of the notion. A professor in a well-known university has a stock question that he asks year after year concerning who shall meet the expense of a proposed scheme for social improvement, and the invariable answer is: "Let the government pay for it."

Along with the idea that the government possessed an all but inexhaustible store was the collateral feeling that doles should be given to

citizens from this property. The land grants made this familiar to the mass of the people and accredited it as a practise. Special grants to citizens, if they could be classified in any way as developmental in their outcome, were favored. Farms, franchises and tariffs were freely given and received. What are referred to now as "special privileges" were merely species of an approved genus.

When the ideas that the country was boundlessly rich and that it should be lavishly generous prevailed, it is not to be wondered at that the officials who were administering the division of the wealth should feel no hesitancy about taking toll of whatever passed through their hands. Graft was a normal collateral result of current practise and is to be distinguished from embezzlement or larceny. The officers were like men passing through a dripping orchard. To pluck and eat was to follow a natural impulse, easily yielded to when everybody was receiving according to their needs.

Out of these conditions of our first hundred years came the ethics of acquisition as a result of our method of exploiting a rich continent; a code which justified the accumulation of wealth by the process of taking it. This was normal and natural. The pertinent question now is, why has it become, or why is it becoming immoral?

A structure is no more stable than its foundation. The phase of public morals discussed here rested upon the fact that the people were carving up the public domain and trying to increase the value of their individual portions. When the good lands of the common heritage had passed from the government's control the general run of citizens had nothing to expect from the public directly. With the extension of the network of railways and other methods of communication over the country at large and the local areas as well, and after the rise of manufactures on a large scale, the prospect of further benefits from further opening of the country did not exist for the major portion of the people. When the populace can no longer look for immediate or collateral benefits of a private nature from governmental grants the policy of distribution is doomed in a democracy. Donations widely scattered may be approved, but if the range is narrowed they become evidences of favoritism and discrimination. As soon as the voters become conscious of the situation they will wipe out the remnants of the system. While "conservation" means both preservation of our natural resources in themselves and their future use for the people as a whole, the popular support behind the movement at present is in the nature of a demand that "landgrabbing" be stopped. What can no longer be done by all will not be permitted to any.

The swift growth of population has exhausted what once seemed to be a limitless territory. With the disappearance of good free lands falls the notion that the government of itself abounds in wealth. Men have

come to realize that they have been seeing darkly and now find themselves face to face with the fact that the government is no richer than the possibility of levying upon the income of its citizens. Favors granted by legislation are seen to mean that the hand of the tax and customs collector must be thrust into the pockets of the people to secure the necessary funds. As the realization of this simple truth becomes wider spread self-interest and the spirit of democratic equality rises against the practise. The vigorous opposition to ship subsidies in recent congresses are indicative of the new tendency. All grants by government, direct and indirect, are being more rigorously scrutinized, and none more so than that of protection against competition. Without enumerating the various influences that have produced the present chaos in practical politics, it is safe to say that while the tariff directly affects the cost of living, the present complaints against the recent legislation is due, not so much to an increased burden of duties as to a new sensitiveness to any duties that may seem to carry special benefit to a few at the expense of the many. The mind of the average citizen is reflecting the change that is taking place in his economic status. He no longer thinks of himself as a beneficiary in the development of the country due to the establishment and growth of great manufacturing businesses. He now sees that he is a consumer. When he used to pay out his money for protected articles his thoughts turned to the collateral gains that were expected from the country's expansion. Now he parts reluctantly with the price demanded because the only return is the goods received in exchange, and the additional cost due to the tariff comes to be regarded as an unwarranted exaction. There is no prospect that there will be any further expansion in which he can share. His economic interest lies in the present and forces him to buy his necessary commodities as cheaply as possible, so that the tariff becomes an object of hostility. The attitude to-day is not merely the result of an era of high prices due to other causes in addition to the tariff; it is not a temporary agitation stirred up by trouble-making partisans; it is a change in mind of the people due to a change in fundamental economic facts.

When the people begin to realize that they have to foot all the bills of the public service, directly or indirectly, and that there is no entity called "the government" upon which the burden can be laid; when it is clear that the government is simply themselves in their organized capacity, the institution of graft begins to totter. There arises a strong resolution to examine critically the expenditure of public funds when the private citizen feels that he is contributing them. Exactness and economy in the conduct of the common business and the administration of governmental affairs begins to be demanded from those officials who were formerly suffered to share in the distribution of the riches that figured as part of the public aid and encouragement given private individ-

uals with a view to social development. New occasions have taught new duties. When the idea of government in the rôle of Lady Bountiful is a thing of the past the practises that grew out of it and were more or less a part of it will have to go also. Doubtless there will always be peculation and rascality in the management of the people's affairs, but graft as an institution will cease to be overlooked and become disreputable.

In contrast with earlier practise the granting of franchises and other "special privileges" is being hedged about with limitations and restrictions unknown to our fathers. The new spirit of thrift in the body politic prevents the fast and loose dealing with valuable rights common in the flush days of exploitation. The worth of the privileges is better known now and it is actually greater. The need of conserving all the sources of public income is felt more and more so that there is a demand for *quid pro quo* when a grant is sought. The work of these companies in building up transportation, lighting and other general conveniences to their present stage has made communities more independent of them and the increase in demand for investments has strengthened the public position. More abundant capital needs opportunities for earning interest, while the body of the citizens have reaped all they can expect from the collateral increase in the value of their property that resulted from the pioneering done by the companies. They are ceasing to give away franchises because they do not need to do so any longer in order to secure the improvements and because the members of the community do not see a chance to participate in the resulting gains. The old methods are becoming immoral.

From what has been written it is perhaps apparent that the current agitation is not a reform movement that is leading to a departure from the error of our ways, but a conversion that is changing the whole of our attitude toward many public questions. The spread of the population, the division and occupation of the territory, the development of the country in transportation and manufactures have been part of the eager struggle for the treasures of a new continent in which grants of land, extensions of public credit, protective tariffs, franchises and tacit permission to graft have been prominent features. The ends sought have been accomplished and the means that were formerly reputable because commonly shared are now condemned. They can no longer be general in their effect either directly or indirectly. When they are confined to a few they cease to be benefits and become favors; and favors are odious in a democracy. The old policies are passing away because the old economic basis upon which they rested and from which they arose has passed away. The enemies of the old order have come in like a flood, not because of a particularly high moral tidal wave but because the shore has subsided. What is going under water now is going to stay

under. These sunken rocks will wreck many a politician's bark in the next few years. Until the change has become definite and the new coast has been charted there will be no safety on political seas. The present confusion of mind makes it difficult for constituents and representatives to understand each other. Chance and whim will determine more than a few public careers before the transition is gone through.

The story of this phase of our economic activity can be compressed into a few sentences. An energetic people possessed with the spirit of equality, and working on an undeveloped domain, flourished forth in a democratic era of acquisition, exploiting natural resources and each other. Now that the natural wealth has been so largely appropriated, it is no longer possible for the majority of the people to continue their former practises, and they have been demanding through a few of their representatives that the minority also cease. This was insurgency.

When the new spirit began to possess the people they endeavored to enact legislation or repeal laws and reorganize administration with a view to abolishing the antiquated institutions and practises that had become odious. They found, however, that the specialization of function had gone so far that there had grown up a governing class of politicians, office holders and administrators fairly distinct from the mass of the citizens. This caste removed from the pressure of new conditions that were changing the lives and thinking of the people in general is dominated by the traditions, customs and practises of an earlier period. The code of ethics of the era of acquisition still obtains among the governing group because the members of this group have not been exposed to the influences to which the common people have been subjected. The representatives of the people now in office represent the people of earlier generations—not their contemporaries. The leaders are in the rear, and persist in staying there. This inability to catch step, this moral inertia, is leading an increasing number of people to doubt the workableness of representative government. When a candidate is elected he enters into the governing group: the atmosphere he breathes is fifty years old: he is soon behind the times. He does what was formerly acceptable, but is no longer so. He does not represent his constituents, for the simple reason that they do not look upon the public affairs as their fathers did. The constituents have changed—the representatives have remained the same.

The extreme difficulty of bringing up to date the machinery of government as at present operated is what is behind the movement for the initiative and referendum that has enrolled within its ranks great numbers of men who have hitherto regarded the proposals of direct legislation as impracticable, cumbersome and out of the question in political units of any great size. Their old objections are as valid as ever they were for a situation in which the people and their representatives are

morally synchronous. But that is emphatically not the present condition. The period of transition has made it necessary to shorten the pendulum of representative government to make it move as fast as the people wish it to go. The voters have repeatedly tried to set the clock forward by electing new men to office, but the new men after election soon fell into the old swing. Direct legislation seems to be the only way to keep those elected to represent the present from falling into the practises of those who represented the past. Its strength as a political issue lies here. Its function will doubtless be temporary. When it has done its work, it will have made government really representative again and itself doubtless fall into disuse.

Looking at the initiative and referendum thus in the best light leaves one, however, with a decided feeling that the agitation for them is pretty much a "talking point" in the process of developing public interest in changing the methods of public business, very serviceable, of course, to the candidates who are conspicuously eager to "trust the people." As a matter of fact, direct legislation to be successful, will need keen and intelligent public interest. Such an interest would result in a wiser choice of more responsive representatives and accomplish the same results with less strain on the electorate. The disinterested advocates of changes in the mechanism of government in this case are over-emphasizing the form to the neglect of the spirit. The new attitude of the public mind will soon be sufficiently strong to secure complete expression in government with or without the aid or hindrance of direct legislation.

No one may expect the new weapons to destroy quickly the old institutions that have become abuses. They are too well rooted to die without a struggle: but in time they will die. There is no longer that upon which they can live.

HELPS TO STUDYING

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TO study means to concentrate the mind and attention on a subject, and to keep it there until the difficulties are mastered and the subject understood.

Aside from the philosophical principles involved in absorption of the mind upon one idea or in one line of thought, there are certain physical or even mechanical aids to this end which are well to know. The writer is not skilled in mental philosophy, but has observed certain simple facts pertinent to the subject of studying which may assist others, and therefore he takes this opportunity of setting them forth. Any one can easily determine for himself how true they are, or whether they apply to him personally or not.

The first enemy to concentration is a roving attention, the coming up into the mind of thoughts or recollections foreign to the matter being studied. I have seen a student, supposedly hard at his task, fix his eyes abstractedly on a corner of the room and think for five or ten minutes of something else, then suddenly recollect that his lesson was not being thus mastered, and with an effort, and perhaps a yawn, bring his attention back to his book. Such a youth is in a pretty bad way, as far as study is concerned, yet the remedy is simple, if he will apply it. I have spoken of the *effort* to bring his attention back to the book; let him, as soon as he feels the inclination to let his attention wander from the book, make the same effort to *keep* it there, and he will nip the evil in the bud. It is no harder, surely, to hold the attention, to prevent it wandering, than it is to bring it back after it has wandered. But, said youth may say "That is fearfully hard work"; to which we reply that study is admittedly hard work, but the hardest part of it is just this effort to keep the mind steadily on the subject studied. What we mean is, that the student must make a hard, determined and earnest fight to keep his attention from roving, that he must fetch his mind back to the straight road by a vigorous mental effort, as soon as he finds it tending to stray, just as a skilful driver reins his horse back into the highway the instant he sees it turn towards a byway. Keep your mind and its activity well in hand, be its master and compel it to do what you want it to do. Such is mental power.

The next enemy is noise or interruption of any kind, be it even so melodious as the finest music. It acts, of course, by distracting the at-

tention. Drafts of air fluttering a curtain, a door banging, heavy or rapid foot-steps, whistling, singing; above all talking. Here is where students can help each other, by gentlemanly consideration for each other. One's ears are always "at attention" when studying, and everything heard distracts attention to some degree; the only exception is a steady drone or buzz, which becomes unnoticed because of its steady continuance. It is impossible, we admit, to provide absolute silence for the student, but fellow students should minimize as far as in their power all disturbing noises in their houses or dormitories, and the boor who insists on "disturbing the peace" unnecessarily should be given his walking papers; he is the common enemy.

Another cause of distraction is a common one in American student life, and exists just because of his abundance of creature comforts. This is the proneness of the student, or possibly of his well-meaning but misguided mother or sisters, to make his room *attractive* by means of pictures, by souvenirs on the walls and tables, by bric-à-brac of various kinds scattered about. When to this are added the various mementos of jubilant class-dinners, rushes, midnight raids on street signs, perhaps even a souvenir of a night in jail, need I say how these *distract* the student's attention from his book. One roving glance, and the family group reminds him of home, that class picture reminds him of his comrades, the flaming poster reminds him of the excitement of his freshman experiences, the policeman's club reminds him of the street row when on a sign-stealing expedition, etc. Need it be said, that, when this unfortunate wight is trying to study, he does not need to be reminded of these things as an aid to concentration, that souvenirs do not help him to keep his attention on his book, and that the more *attractive* his room is the more it *distracts* his attention. I do not confound attractiveness with comfort; the latter the student should have, the more the better, but the comforts should be real, unobtrusive ones.

I am simply protesting against that misguided custom which often regards students' rooms as *olla podrida,* museums of bric-à-brac, proper depositories of any and every object which can remind the student of the glorious life he is leading—and which are all common enemies, to a smaller or greater degree, to that concentration of mind which he most needs, as a student, to cultivate and to possess.

However, the room must have something in it, the walls should not be those of a bare attic, let us admit, and therefore, what is the student to do, when studying? On this head, we have two suggestions to make, which have been tried and found effective. First, when studying by daylight, have the table near the window, so that the light is sideways, and one's back is partly towards the "attractive" room. If the window gives on a busy street, have the lower half covered by a translucent curtain, to keep the attention from being distracted by happenings outside. If the window looks out on a quiet neighborhood, or

especially on a country scene, the curtain is unnecessary. The best situation is where there is a rather extensive view from the window, for then the student can from time to time rest his eyes, wearied by their short focus on the book, by letting them focus on the distance, the farther away the better, without there being any moving factors in the scene to particularly claim attention. Under these circumstances, his eyes being rested, but his attention not caught, the student's mind will often go back naturally to what he is studying, and will reflect on the points just learned. Given such a window, with such a view, and absence of unnecessary noise, and the student should do good work in daylight.

At night the conditions are very different. Artificial light must be used, and of what kind and how placed is all-important. The writer may have had limited experience in some of these regards, but the following are the results of his observation, and are given for what they are worth:

First, the illumination should not be general. The only matters concerned are the student and the book, and as the student will get his illumination from the book, it is only the proper lighting of the latter which is to be considered. A lighting scheme which lights the whole room is worse than useless, it is undesirable. The better the book is lighted and the more the rest of the room is in comparative darkness, the easier it is for the student to keep his attention fixed on the book and the less is he distracted by seeing the other things in the room. Is it not an old trick of the artist, to focus and hold the attention by a brilliantly-colored "center" (such as the child's face in Correggio's "Holy Night"), in the midst of an obscure back-ground? Therefore, applying common sense as well as artistic perception, illuminate the book to be studied as much as is necessary, and the rest of the room as little as is necessary. By so doing, concentration on the book is wonderfully assisted.

Second, place the light in front and preferably to the left. We are not here speaking of how to sit in an easy chair and read a novel most comfortably, with the light coming over one's shoulder; but we speak of the student with a book which needs mastering, probably with pencil in hand and a pad of paper alongside. Such requires the student sitting squarely at a table, with his paper and pencil ready for action. In this case, the light should be close, not over three feet away from the book, better at half that distance, so that practically only a small circle is illuminated, with the book nearly in its center. If placed directly in front, the glaze on the paper may easily interfere with reading; and if writing (with the right hand), placing the lamp to the right will be likewise annoying because of the reflection from the glaze. The best position is for the light to be to the left a few inches, as far forward as the top of the book or paper, and no higher than the eyes. A green

shade over the light, enamel-white inside, is the best. A white shade lights up the room in general too much, and necessitates the student wearing a green eye-shade on his "noble brow." The latter is uncomfortable, and quite unnecessary if put over the light instead of over his eyes.

Third, a student oil-lamp gives the most satisfactory illumination, if kept in good order. The wick should be kept free from excrescences, so that it always gives its proper, steady, mellow, yellow light. The ordinary gas burner flickers too much, the electric light is steadier but can not be regulated, the Welsbach-mantle light is too brilliant if turned on full and too variable if turned down.

Fourth—and most important of all—turn the light down low, and then turn it down some more! Given the right kind of light, the student lamp, one third to one half its full illuminating power, is all that is necessary or desirable. The reason is highly important. for reading easily and for the welfare of the eyes, and it is this: We see the print by contrast of nearly black against nearly white; with no illumination there is no contrast; as the illumination increases the contrast becomes better and reading is easier. At a certain point, the contrast is greatest and reading is easiest. But it is an entirely erroneous idea that the greater the illumination the greater the ease of reading. Hold the page directly in the sunlight; can you read it easier? There is a certain amount of illumination at which the contrast of print against paper is a maximum and where reading is easiest, with least fatigue to the eyes. This point varies for different-sized prints, for different inks, for differently surfaced papers and for different tints of papers. The point can be readily and easily determined in a fraction of a minute, in any particular case, by any one wishing to find it, by simply turning the light slowly up, keeping the eyes on the book, and noting the *least* light at which the print is clearly seen and read without sensible effort. This is the point at which you can read that book the longest without strain or fatigue; it will usually be found at about one half or less of the illumination ordinarily used. (I will not speak of the saving in "midnight" oil thereby attained; the saving in "eyes" is more important.) One can often read and study for hours with this light, whereas a brighter light would really make reading more difficult and tire out the eyes in a fraction of the time.

The effect of heeding and using the above principle is that eye-fatigue is minimized and thus study is done with less distraction from this cause. The point explained is the point of maximum comfort, and, therefore, of maximum efficiency. With only the book illuminated, and lighted just to the point of maximum comfort, all other objects in the room in semi-darkness, and the student anxious to study, let us leave him to himself, to see what he can make out of the situation.

BEES WHICH VISIT ONLY ONE SPECIES OF FLOWER

By JOHN H. LOVELL

WALDOBORO, MAINE

ONE warm afternoon on the twentieth of July I was collecting insects from a boat on the Medomac River. A thunder-shower was coming up in the northwest. The air was very still and in that peculiar condition which precedes an electric storm. At such times insects are very sluggish and seek shelter against the approaching tempest. The silence was broken only by the rumbling peals of the distant thunder, following the bright flashes of lightning, which illumined the dark thunder-heads of the advancing clouds. It became necessary for me to hasten homeward. To my surprise I noticed on almost every one of the violet-blue spikes of the pickerel-weed (*Pontederia cordata*), a species of water hyacinth, which in countless numbers fringed the winding stream on both sides, one to several small bees. They had crept within the bilabiate flowers as far as possible, and were evidently intending to await there the passing of the storm. They were so inactive that no net was required, and I could easily knock them off into the cyanide jar. I collected about forty specimens and could have easily collected hundreds. This phenomenon has never been repeated to my knowledge.

On examination the bee proved to be *Halictoides novae-angliæ,* or the pickerel-weed bee. Every season when the pickerel-weed is in bloom I find both sexes of this bee on its flowers, and though I have carefully observed the visitors to many other plants in this locality I have never met with it elsewhere. Apparently in this region it never visits any other flower—it is a monotropic bee. When a female bee in gathering pollen for brood-rearing visits but one kind of flower it is termed a monotropic bee, or if only a few allied species an oligotropic bee; but if it visits many flowers it is called a polytropic bee. These terms were first proposed by Dr. Loew, and signify adapted to one, few or many flowers.

It is impossible not to feel some curiosity as to why this little bee restricts its visits to the inflorescence of the pickerel-weed. Notice that it flies only at the season of the year when this aquatic plant is in bloom, and that it finds within the perianth both food and shelter. Very likely its nests are built not far away. The flowers of the pickerel-weed strongly attract insects by their great numbers, bright hues, pleasant fragrance and abundant nectar and pollen; and consequently are sought

out by many bees, flies and butterflies. Bumblebees especially delight in these blossoms, which they visit with astonishing rapidity—*Bombus consimilis* making about seventy visits per minute. On the middle lobe of the upper lip there are two bright yellow spots, which tell of the presence and guide to the exact location of the nectar concealed within the tube of the perianth. When the pickerel-weed bee makes its appearance about the middle of July, there is no other flower in southern Maine which can offer it so many inducements as the pickerel-weed. But let us look farther and see if there are any other bees, which behave in a similar manner.

In the quiet bays of the river, floating upon the surface of the water, bloom the yellow water lilies (*Nymphæa advena*).

> Again the wild cow-lily floats
> Her golden-freighted, tented boats,
> O'ershadowed by the whispering reed,
> And purple plumes of pickerel-weed.

The flower is securely anchored to the bottom of the stream by a long stem. At first the opening in the bud is no larger than a bee's body, and the chamber within offers a dry and snug shelter amid the waves. It may truly be called a haven of refuge. Directly below the entrance is a broad, many-rayed, crown-shaped stigma, as in the poppy. The petals are thick, wedge-shaped bodies which are orange-yellow on the outer side near the top, where they freely secrete nectar. Under a microscope both large and minute drops can readily be seen. The stamens are indefinite in number; and reveling in the pollen, their bodies completely covered, there is a large and lively company of small flies called *Hilara atra*. Less common are two beetles, *Donacia piscatrix* and *Donacia rufa*; but what chiefly interests us is a small bee, *Halictus nelumbonis*, or the water-lily bee. This bee in this locality is never found on any other flower, but elsewhere it is met with on other species of the water-lily family, or Nymphæaceæ. It is an oligotropic bee, and the only species of the great genus *Halictus* that is known to behave in this way.

But in *Andrena* this is a common phenomenon, for instance, in Washington County, Wisconsin, according to Dr. Graenicher, twenty-four of the forty-seven indigenous species of *Andrena* are oligotropic. This is the largest genus of North American bees. They are sometimes called ground-bees, since they build branched tunnels eight to ten inches deep in the soil of sandy pastures and hillsides. A part of the species are vernal or fly in springtime, while a part are autumnal and fly only in autumn. They provision their cells with balls of "bee-bread," about the size of a garden-pea, composed of pollen moistened with nectar. An egg is laid on the top of the mass of bee-bread, and the cell is then closed.

The bright yellow staminate aments of the pussy-willow (*Salix*

discolor) are great favorites of vernal species of *Andrena*, whence Smith calls them "harbingers of spring." The pussy-willows bloom in northern New England during the latter part of April, and their bright yellow aments are very pleasing objects in the cold gray landscape. They are very attractive to a varied company of insects, as honey-bees, bumblebees, flies, butterflies and beetles. It is a busy scene and one which the naturalist can never tire of watching; but it is not one of unmixed happiness, for little tragedies take place before our eyes. Among those which come to sip the nectar are little dance-flies (Empididæ), and not infrequently they are seized and carried away bodily by black robber ants, which roam everywhere. Honey-bees and many species of *Andrena* come in great numbers to procure pollen for brood-rearing. A part of the Andrenid bees gather only a portion of the pollen they require from the willows and the balance from the maples, plums, cornels and *Viburnums;* but there are four species (*A. illinoiensis, A. mariæ, A. erythrogaster* and *A. moesta*), which get their whole supply from this genus of plants. Of the autumnal flying species of *Andrena* there are five (*A. canadensis, A. nubecula, A. solidaginis, A. hirticincta* and *A. asteris*), which I have collected only on the flowers of the Compositæ, or aster family; and four of these bees confine their visits very largely to the golden-rods. In both *Salix* and *Solidago* the inflorescence offers an ample supply of nectar and pollen and there is little temptation for Andrenid bees to go elsewhere, when their time of flight coincides with the period of blooming of these two genera.

But in other localities *Andrena erigeniæ* is reported to be a monotropic visitor of the spring beauty (*Claytonia virginica*), *Andrena violæ* of the violet (*Viola cucullata*), *Andrena geranii maculata* of the wild geranium (*Geranium maculatum*), *Andrena fragariana* of the strawberry (*Fragaria virginica*) and *Andrena parnassiæ* of *Parnassia caroliniana.* It is not so easy to explain the behavior of these latter bees. It seems very remarkable that they should restrict their visits so closely to the flowers mentioned.

Macropis ciliata, or the loosestrife bee, usually gets its pollen from the flowers of the common loosestrife (*Lysimachia vulgaris*); while many species of *Panurginus* are taken only on the inflorescence of the Compositæ.

But this habit of visiting only one kind of flower is perhaps better illustrated by *Perdita* than by any other genus of bees. Only one species of *Perdita* is found in Maine; but in the western states some 90 species occur, of which about forty live in the arid regions of New Mexico. In Maine *Perdita octomaculata* is found almost exclusively on the panicles of *Solidago juncea,* the earliest blooming of the golden-rods; and I have never met with it on any other species except in one instance. In New Mexico two species of *Perdita* are found on the willows, *Perdita zebrata* visits only *Cleome serrulata, Perdita crotonis*

visits *Croton texensis, Perdita albipennis* visits *Helianthus annuus* (sunflower), and *Perdita senecionis* visits *Senecio Douglasii.* "It may be laid down as a rule," says Professor Cockerell, "that each species of *Perdita* visits normally but one species of flower, but occasionally specimens may be found on flowers to which normally they do not belong." But in many instances several species of *Perdita* frequent the same flower. The bees of this genus are small forms very frequently marked with bright yellow.

Many species of *Colletes, Epeolus* and *Melissodes* visit almost exclusively the flowers of the Compositæ, as the thistles, golden-rods and asters. *Xenoglossa pruinosa* confines itself to *Cucurbita pepo* or the common field pumpkin; while *Megachile campanulæ,* one of the leaf-cutting bees, is a monotropic visitor of the bellflower *Campanula americana.* Many other instances are recorded, and many more will no doubt be discovered when our bee fauna is better known.

This is certainly a very singular habit on the part of bees, and one which could hardly have been foreseen. On the contrary, it is generally supposed that bees fly about sipping sweets indiscriminately, as they are so commonly represented by the poets.

> He woos the Poppy and weds the Peach,
> Inveigles Daffodilly,
> And then like a tramp abandons each
> For the gorgeous Canada Lily.

It is really getting unsafe for poets to write about nature in their old, haphazard way, trusting chiefly to their imagination as a guide. Fancy can supply nothing half so wonderful as the true facts about flowers and insects. Let us consider what theories naturalists have advanced to explain this curious habit!

In Kerner's day only a few oligotropic bees were known, and he believed that they gave the preference to certain flowers because they found their odors so highly attractive. But it is incredible that so many bees should be dominated in their flight to such an extent by various floral odors, and besides they not infrequently visit several flowers which differ in scent. No doubt, though, bees have their preferences in odors and nectars, and probably they prefer pollen that has a roughened or spined surface to that which is smooth.

A more probable explanation claims that female oligotropic bees have adopted this method of visiting flowers to avoid competition in gathering pollen for brood-rearing. This theory is only partially satisfactory and certainly is not always applicable, even assuming that such a partition is beneficial or required. The four species of *Andrena,* which in this locality visit exclusively the willows, do not thus avoid competition nor do they thus benefit other bees. The willow aments have pollen enough for all comers. In this particular case this habit seems to have arisen because it was advantageous to these bees to re-

strict their visits to flowers so abundantly supplied with pollen and nectar, combined with their early and short time of flight, which lasts only about a month, and perhaps also to their nesting near these shrubs. Where bees fly only during the latter part of the season it seems very natural for them to restrict their visits to the Compositæ. These flowers, as in the case of the golden-rods and thistles, are very common, contain ample food supplies and are easy to visit. They are actuated not by the need or desire of avoiding competition, but by the same motives which lead honey-bees to visit the white clover exclusively while it is in bloom.

The oligotropic habit is not beneficial to flowers, it concerns the bees alone. The oligotropic bees are almost without exception solitary forms, to which there are no flowers specially adapted. The social bees, as a rule, visit a great variety of flowers, though in Europe it is stated that there is a bumblebee (*Bombus gerstaeckeri*) which visits a single species of monkshood (*Aconitum lycoctonum*). Here, of course, the adaptations are mutual. This mode of flight, however, has not in general been determined by floral adaptations. Certain species of bees have become satellites of certain flowers because of the advantage thus gained for themselves, and partly also perhaps as the result of habit. Just as there are fly-flowers, butterfly-flowers and bumblebee-flowers, so, on the other hand, there are willow-bees, golden-rod bees, a pickerel-weed bee, a loosestrife bee, a violet bee and a strawberry bee.

Two most important influences are the season of the year and the length of time the bee is on the wing. It is clear that bees which fly only in spring or autumn for about a month have not a great choice of flowers; and, of course, we never look for autumnal bees on spring flowers. Usually the length of time an oligotropic bee flies and the flower it visits is in bloom are about the same. The honey-bee is practically a monotropic bee at certain seasons of the year. While the basswood and white clover are in bloom the honey-bee visits these flowers almost exclusively. Again in the fall in Maine it confines its attention solely to the golden-rods. In California at times it collects nectar exclusively from the sages; in Michigan from the willow-herb, and in other regions from other plants. If from any one of these plants it also obtained its supply of pollen and was on the wing only while it was in bloom, it would be regarded as a monotropic bee in the strict sense of the word. That it exhibits a strong tendency, when collecting pollen, to be constant to one plant species is well known; and the little packets of pollen it brings into the hive seldom consist of two kinds of pollen. But when a bee flies from spring till fall and requires a large amount of stores, it is evident that it can never become oligotropic.

Another important factor is the small size of many oligotropic bees. This is true of *Prosopis nelumbonis*, *Halictus nelumbonis*, and many

species of *Panurginus, Perdita* and *Andrena*. These bees have a weak flight and are not fitted to travel long distances. It is known that in some instances they build their nests near the flowers they visit. Probably this generally true. The medium-sized oligotropic bees, belonging to the genera *Colletes, Epeolus* and *Melissodes,* fly in the fall and visit chiefly the Compositæ, a family which offers a wide choice of flowers. It is not always easy here to draw the line between an oligotropic and a polytropic bee.

There are still in existence many intermediate stages betwe n monotropic, oligotropic and polytropic bees. While many bees visit a great variety of flowers, others visit only one family, as the Compositæ or Nymphæaceæ, others only a single genus, as *Salix,* and others only a single species, as the violet, strawberry or spring-beauty. Many exceptions no doubt occur and will be recorded when the habits of these bees have been more carefully observed. For instance, I have often seen the loosestrife bee on the umbels of the prickly sarsaparilla. It is evident that if a monotropic bee extends into a region, where the flower it visits elsewhere does not occur, it must of necessity visit other flowers. Dr. Graenicher writes me that the pickerel-weed bee (*Halictoides novæangliæ*) is found in Wisconsin; but the pickerel-weed does not flourish in the same locality, and so this bee is compelled to visit the blossoms of other plants. Evidently this habit did not originally exist among bees, but has gradually been acquired.

We may sum up the matter as follows. All bees including the honey-bee show a strong tendency in collecting both nectar and pollen to be constant to one species of flower. This is manifestly for the advantage of both insects and flowers. In the case of a number of bees flying for only a small part of the season this habit has become so specialized that they visit only one or a few allied species of flowers, which offer an abundance of pollen and nectar. Primarily it seems to be the direct advantage gained rather than the avoidance of competition that has led to the rise of the oligotropic habit. As the honey-bee for a time restricts its visits to the white clover, so in like manner a monotropic bee visits but a single kind of flower. But in the former case the bee flies throughout the whole season, but in the latter when the flower fades the bee's period of flight is over.

The idiosyncrasies of bees in visiting flowers present many remarkable peculiarities, and undoubtedly offer an attractive field for observation. There are certain bees, which though they are not oligotropic obtain the larger part of their supplies from comparatively few flowers, as the plums, thornbushes. cornels and *Viburnums*. In this locality one of the leaf-cutting bees (*Megachile melanophæa*) shows a decided preference for the purple vetch (*Vicia cracca*), and if I desired a specimen I should look for it on the blossoms of this plant. As the parasitic bees do not provide stores for their brood and seek nectar for themselves alone, they show little preference for special flowers. For a simi-

lar reason the males of any species of bee may not visit the same flowers as the females, though the attraction of the female may largely influence their course, in which respect they exhibit quite human sentiments. It would, of course, be in vain to look for the males of *Bombus* and *Halictus* on the flowers of spring, since they do not appear until mid-summer. In the case of diœcious plants, or plants in which the sexes are on different individuals, the bees visiting the staminate flowers are more numerous and are sometimes widely different from those visiting the pistillate. The common sumach is a good example. Indeed the bees visiting a flower in its early stages may differ from those visiting it in its later stages. Again the visitors to a flower may differ, both in number and kind, in different seasons.

The depth at which the nectar is concealed is another most important factor in controlling the visits of bees. In some flowers it is fully exposed on a flat surface where it is accessible to all insects; in others it is at the bottom of a slender tube, where it can be reached only by the larger moths. The familiar fable of the crane and the fox is constantly illustrated among flowers. As a matter of fact, bumblebees and butterflies avoid rotate, flat flowers containing little nectar, since their long tongues do not permit them to suck easily on such a surface. On the other hand, it would be useless to look for the smaller bees with short tongues on the larkspurs and clovers, for the nectar is quite beyond their reach.

As we take our leave of the oligotropic bees it may be inquired if there are any other insects, which visit only one species of flower. There are many others, especially among butterflies and moths. The flag beetle (*Mononychus vulpeculus*) passes its entire life on the blue flag (*Iris versicolor*). This small weevil feeds both on the pollen and nectar and sometimes gnaws the flower-leaves badly. The eggs are laid in the young seed capsules, where the larvæ feed on the ripening seeds. Both the adult beetles and larvæ are supported at the expense of the blue flag. The legitimate pollinators are bees and while the flag beetle may rarely effect pollination it does far more harm than good. This symbiotic relation is a benefit to the insect, but an injuiry to the plant.

Two slender metallic-hued beetles (*Donacia rufa* and *Donacia piscatrix*) find very comfortable quarters within the flowers of the yellow water lily, where they idle away much time drinking nectar and eating pollen. They lay their eggs on the leaves and the larvæ burrow in the stems. As in the case of the flag beetle this arrangement is evidently more to the advantage of the beetles than of the plants.

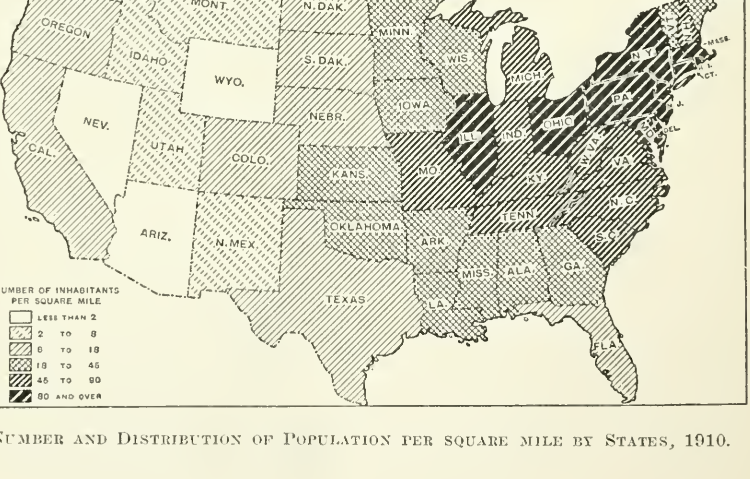
The night-blooming yucca, or Spanish bayonet, which flourishes throughout the southern states, is pollinated exclusively by a small nocturnal moth. The larvæ of the moth live in the seed-capsules. Thus both plant and moth are reciprocally dependent on each other, and the destruction of the one would be followed by the disappearance of the other. But in most instances the insect receives the greater benefit.

THE PROGRESS OF SCIENCE

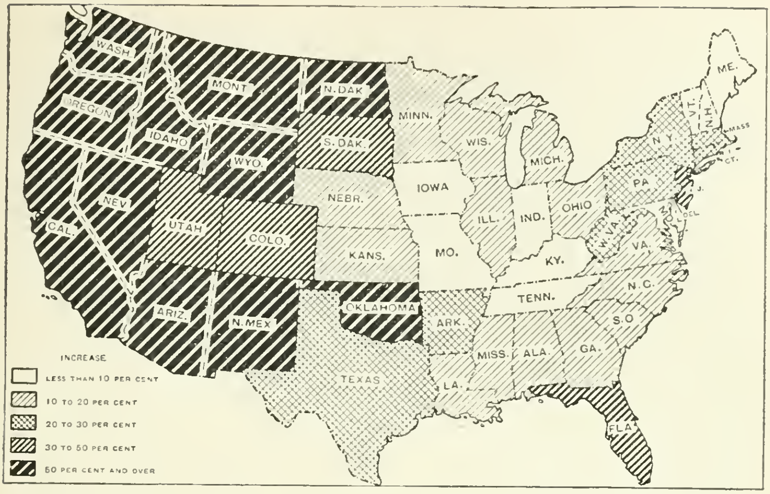
THE POPULATION OF THE UNITED STATES IN 1910

The Bureau of the Census has now issued a bulletin giving the official figures of the thirteenth census, preliminary statements of which have from time to time been made public. The population of the United States was 93,402,151, of which 1,429,885 belongs to the non-contiguous territory of Alaska, Hawaii and Porto Rico and persons in the military and naval service stationed abroad. There are still to be added the inhabitants of the outlying possessions of the United States —some eight millions—nearly all in the Philippine Islands. The percentage of increase from the preceding census is 21, being three tenths of a per cent. larger than for the preceding decade. The population of the United States shows an increase of about one third during each of the seven decades from 1790 to 1860, of about one fourth during the three decades from 1860 to 1890 and of about one fifth during each of the last two decades. Thus while the increase in population over the preceding census continually increases, the percentage of increase becomes continually less, and there is no reason to suppose that the population will increase indefinitely. Indeed, if it were not for foreign immigrants and their larger families, the increment of increase of the population would be very small. It should, however, be added that there are those who hold that the native population would increase more rapidly if it were not for the large immigration.

The density of population and the increase of population, as shown on the accompanying maps, are very unequally distributed over the United States. There are ten states in which there were in 1910 a population per square mile of more than one hundred. Rhode Island with 508, and Massachusetts with 418 are the most densely popu-



NUMBER AND DISTRIBUTION OF POPULATION PER SQUARE MILE BY STATES, 1910.



Per cent. of increase in total Population by States, 1900–1910.

lated states, followed in order by New Jersey, Connecticut, New York, Pennsylvania, Maryland, Ohio, Delaware and Illinois. The least density of population is in the mountain states, Nevada with less than one inhabitant to the square mile ranking the lowest, followed by Wyoming and Arizona. The largest percentages of increase are shown by the mountain and Pacific states, Washington leading with an increase of 120 per cent., followed by Oklahoma and Idaho. As has already been widely noted, Iowa shows an actual decrease in population. The states of Missouri and Indiana show very moderate increases; the rural New England states also show small increases of from four to seven per cent. The increase in New York is 25 per cent. and in Pennsylvania 22 per cent.

The urban population, which includes those residing in cities of 2,500 inhabitants or more, has increased 35 per cent., and the rural population 11 per cent., seven tenths of the sixteen million increase being in the cities. The urban population is now 46 per cent. of the total population, whereas in 1880 it was 29 per cent. The three cities—New York, Chicago and Philadelphia—having a population of more than one million, show thirty-two per cent. increase, while five cities, having a population of 500,000 to one million, show an increase of only 20 per cent. The cities—90 in number—having a population of 50,000 to 250,000 show the largest percentage of increase, namely, 41 per cent. In New England and the Atlantic states about three quarters of the people live in the cities.

THE ERADICATION OF HOOKWORM DISEASE

The second annual report of the Rockefeller Sanitary Commission tells the story of a dramatic achievement of modern sanitary medicine. It will be remembered that the existence of hookworm disease in the south was not suspected until recently. It has now been found to be extremely prevalent. In the infection survey of the commission 87 counties were covered, 37,267 children examined, and the percentage of infection by counties was found to range from 2.5 to 90.2 per cent. In some schools practically every child was infected, and a large percentage of all children were unable to attend school. The disease is particularly disastrous in its consequences, for though not ordinarily fatal, like malaria it prevents

Dispensary group at public school building, Fairmon, Robison County, N. C., July, 1911. Treated at the place on that day, 187.

the individual from doing his ordinary work, reducing, it is said, his efficiency to less than half. A good part of the inefficiency, laziness and lack of enterprise of the white people of the south is attributable to the infection. It is further a disease which is both curable and preventable, and it is in such a case that medicine and hygiene have their great opportunity.

Some 75,000 persons were treated at the initiative of the commission, and much was accomplished by spreading knowledge as to the means of preventing soil pollution. Indirectly the commission has had the effect of awakening interest in health conditions throughout the south, so that state boards of health have become more active, and superintendents of health giving their whole time to the work have been appointed in various counties. The commission has also undertaken to obtain information in regard to the hookworm disease in foreign countries. In Europe, except in Italy, the infection is practically confined to miners, and is found in only a few well-defined localities, but in many tropical and sub-tropical countries the infection is extremely prevalent. It is said that 90 per cent. of the working population of Pơrto Rico are infected; on many plantations in Ceylon the infection rises as high as 90 per cent.; of the three hundred million of people in India 60 to 80 out of every hundred harbor the parasite, and conditions are nearly as bad in the southern two thirds of the Chinese Empire.

SYNTHETIC RUBBER

Professor W. H. Perkin, of the University of Manchester, who is the son of Sir William Perkin, the discoverer of aniline dyes, presented a paper before the Society of Chemical Industry last month describing the methods by which synthetic rubber had been produced, and stating that the process is such that rubber can be made as economically as it can be obtained under natural conditions, probably, at a cost of about twenty-five cents a pound. The scientific research was undertaken under the auspices of Mr. Alfred Strange, the work being done largely by Dr. F. E. Matthews, of London, and Professor Fernbach, of the Pasteur Institute. It has been known for some time that caoutchouc, the

THE LATE RALPH STOCKMAN TARR, Professor of Physical Geography, Cornell University.

principal constituent of india rubber, is based on a cluster of at least 10 or 20 molecules of the formula C_5H_8. It thus possesses the same composition as oil of terpentine and other terpenes, which are the chief components of fusel oils. There is a hydrocarbon called isoprene which has the formula of C_5H_8, and it has for some years been known that when this volatile liquid is allowed to stand for some time in a closed bottle, it gradually passes into a substance having the principal properties of natural caoutchouc. The same change may be effected, as Professor Harries had shown, in an article published last year, by treatment with metallic sodium. Dr. Matthews independently made the same discovery. The difficulty was that isoprene is difficult to obtain and is more expensive than india rubber. Professor Fernbach, however, after eighteen months of research, discovered a fermentation process for the production of fusel oil, one of the raw materials of isoprene, from any starchy material, such that the cost will not exceed $150 a ton.

As is well known, the existence of india rubber was learned from the Indian tribes of South America, and the best rubber known, para rubber, still comes from Brazil. In recent years plantations of rubber trees have been set out, especially in Ceylon, and about 300 tons of rubber are produced annually as compared with 70,000 tons from the wild trees. The enormous increase in the commercial demand for rubber, due to many causes but first to electrical insulation and later to the introduction of automobiles, has made the natural supply inadequate and greatly increased the cost. It may be confidently expected that the demand will further increase in the future and that rubber could be used to advantage for many purposes if it could be obtained at less expense. The discovery of the possibility of artificial rubber at a cost that competes with natural rubber is consequently an important application of modern science.

SCIENTIFIC ITEMS

We regret to record the death of Dr. Shadworth H. Hodgson, the British philosophical author; of Dr. Ferdinand Zirkel, emeritus professor of mineralogy at Leipzig; of M. F. Lecoq du Bois-Baudran, the French chemist who discovered gallium; and of M. C. Andre, director of the Lyons Observatory.

A memorial service in honor of Robert Koch was recently held in a temple dedicated to him, which has been erected at Tokyo. The temple owes its origin to the interest of Professor Kitasato.—Lady Hooker will be grateful if any who possess letters written by her late husband, Sir Joseph Hooker, will lend them to her for the purposes of a biography which Messrs. Smith, Elder and Co. will publish.

The nineteenth International Congress of Americanists to be held in 1914 will consist of two sessions: the first in Washington, D.. C., and the second at La Paz, Bolivia.—The International Geological Congress will hold its twelfth meeting in Canada during the summer of 1913. It is proposed to hold the meeting in Toronto beginning on or about the twenty-first day of August. —The program for the meeting of the British Association at Dundee on September 4 and following days includes garden parties at Glamis Castle, Kinfauns Castle, Rossie Priory and Camperdown and excursions to St. Andrews, Dunfermline, Arbroath and Aviemore. The president, Dr. Schäfer, of Edinburgh University, will devote his address to the developments that have taken place during the last fifty years through the study of the tissues of the body by means of the microscope. Professor Bragg will discourse on "Radiations, Old and New," and Professor Keith on "The Antiquity of Man."

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RESEARCH IN MEDICINE[1]

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V. Medical Research in American Universities; Present Facilities, Needs and Opportunities[2]

IF the preceding lectures have a special value, it is in indicating, on the basis of past experience, the methods and mode of approach, which will presumably yield the greatest measure of success in the investigation of present and future problems. Looked at in this light what I have cited of the past shows four important aspects:

1. The epoch-marking labors of isolated individuals working independently.

2. The application of the exact methods of physics, chemistry and biology to medicine.

3. The development of laboratories for the organized and intensive investigation of the various problems of medicine.

4. The idea of diminishing suffering and ameliorating social conditions.

The first of these factors naturally suggest the names of Vesalius, Paré, Harvey, Hunter, Jenner, Morgagni and Haller. Some of these may have been influenced by antecedent work as Vesalius by Herophilus and Erasistratus; Harvey by his forerunners, who studied the circulation of the blood; and all, perhaps, by the old teachings of Hippocrates or the experimental side of Galen's work, but the actual achievement of each, whether the result of chance suggestion, original conception, or keen observation, was the fruit of labors unassisted, prosecuted with

[1] The Hitchcock lectures, delivered at the University of California, January 23–26, 1912.

[2] Presented also before the Academy of Medicine, Toronto, Canada, March 5, 1912.

difficulty, and in most instances in opposition to the traditions of the profession. Such independent effort, though most prominent in the period previous to the year 1800, always has had and always will have a place in medicine. This is seen in the efforts of the individual, even after medicine was influenced by its ancillary sciences and, indeed, in the days of organized laboratory effort. In this connection, one recalls Sir George Baker's demonstration that a form of colic, epidemic in character, occurring in Devonshire, England, was to be explained as a poisoning by lead; Captain Cook's conquest of scurvy; Auenbrugger's invention of the method of percussion; Laennec's invention of the stethoscope; the theory announced independently by Holmes and by Semmelweis of the transmission of puerperal fever and many other independent efforts in the practise of surgery and medicine, as those with which we associate the names of Pinel, McDowell, O'Dwyer and Trudeau.

Modern effort in research in medicine, however, as in science generally, is, it must be admitted, organized laboratory effort, and upon this type of effort present-day progress would seem to depend. Nevertheless, the individual is as important as ever, for "it goes without saying that laboratory buildings alone, even when adequately equipped and with a liberal maintenance budget, are far less important than the men who work in them" (Barker), but the laboratory now offers to the individual, with original conceptions or special talents, advantages, facilities and opportunities which, by aiding and supplementing the work of the individual, render isolated effort unnecessary, time-consuming and often futile.

Under the second head, the influence of physics, chemistry and biology, fall such men as the English physicists and chemists and the French academicians—Boyle, Cavendish, Priestley, Galvani, Faraday, Tyndall, Lavoisier, Gay-Lussac and Berzelius. A more direct influence is seen in the entrance of Pasteur, a chemist, into the field of etiology; of Ehrlich, a physician, but chemically trained, into the field of immunity and specific chemical affinities; and of Metchnikoff, applying the methods of the biologist to the problems of pathology. Likewise Liebig and Wöhler and organic chemistry; Höppe-Seyler and physiological chemistry; Arrhenius and physical chemistry, Darwinism, Mendelism, all have had their influence, and the methods and views they represent have been taken over by medicine and applied to the solution of its problems.

The influence of physics and chemistry in establishing the third factor—organized laboratory effort in special fields of medicine—we have seen in the beginnings of laboratory research in the second quarter of the past century. Virchow at the time he was urging the establish-

ment of pathological laboratories epitomized the history of organization in medical effort as follows:

As in the seventeenth century anatomical theaters, in the eighteenth, clinics, in the first part of the nineteenth, physiological institutes, so now the time has come to call into existence pathological institutes and to make them as accessible as possible to all.

Since then, the laboratory idea has spread rapidly; not alone laboratories of pathology have been founded, but also laboratories of bacteriology, hygiene, physiological chemistry, pharmacology and every branch of endeavor promising advance in the science of medicine. Not only have such laboratories come into existence in university schools of medicine and in hospitals, but many independent laboratories for research alone have been founded in the large medical centers, as the Pasteur Institute in Paris (1888), the Imperial Institute for Experimental Medicine in St. Petersburg (1890), the Institute for Infectious Diseases in Berlin (1891), the Lister Institute for Preventive Medicine in London (1891), the Institute for Experimental Therapeutics in Frankfort (1896), the Rockefeller Institute for Medical Research in New York (1901), the Memorial Institute for Infectious Diseases in Chicago (1902), the Henry Phipps Institute for the Study, Treatment and Prevention of Tuberculosis in Philadelphia (1903). Likewise, municipal, state, provincial and national laboratories, devoted to work concerned with the public health, have been established. Some, following the example of the first laboratory of hygiene, that of Pettenkoffer, founded by the Bavarian government in 1872, have been most active in investigation; others are devoted mainly to the routine work necessary for the conservation of the public health. How essential laboratories of the latter type are is shown by the fact that several states, New York among the first, have established county or district laboratories to care for the problems of communities distant from the state laboratory and the laboratories of the larger cities.

So also laboratories as an integral part of hospitals, the so-called clinical laboratories—the first of which was established by Ziemssen in Munich about 1886—have become a necessary part of every hospital which makes any pretense of accurate diagnosis and adequate therapy. The list might be extended to include also laboratories devoted to special diseases, as cancer and tuberculosis, diseases peculiar to the tropics, and diseases of animals, or to special branches as surgical pathology, neuropathology and psychopathy. This wonderful extension of the laboratory idea in medicine dates only from the simple beginnings of Purkinjé and Liebig in 1824–25. At the present day, Germany alone is said to have over two hundred such medical institutes, and to this policy of establishing laboratories must be ascribed her leadership in the medical sciences since the third decade of the past century.

From this brief recapitulation of the important influences affecting research in medicine, only one conclusion is deducible; that although the individual will continue to be the most significant factor in the situation, it is unquestionable that his perception will be constantly stimulated, his imagination quickened and his hands aided, by the opportunities, ideals and facilities of the laboratory. In the laboratory only can "the prepared mind" of Pasteur's adage ("In the fields of observation chance favors only the prepared mind") be properly fostered. It is in the laboratory, and under this term I include the properly conducted hospital as the laboratory of clinical medicine, that medicine keeps in close touch with new discoveries in physics, chemistry and biology, the second of the three important factors we have discussed. The situation in regard to the auxiliary sciences has not changed since the time of Liebig, Müller and Virchow. The investigator in the laboratory and the investigator in the hospital still look to these sciences for assistance and eagerly apply the discoveries in each of these his own problems. The result is a decided advantage to medicine, not only in that this revivifying and suggestive influence leads to accelerated progress in the science and art of medicine, but also in that it directly influences the health and therefore the welfare, commercial and social, of the community.

This brings us to the fourth factor which has influenced medical research in the past and should—indeed must—continue to be an ever-increasing influence in the future—the desire to ameliorate social condition, by diminishing the causes of physical and mental ills. This, in a word, is the desire for social service; the impulse which actuated all of Pasteur's work, and which he himself expressed as the desire to contribute "in some manner to the progress and welfare of humanity." It is not sufficient that the individual as an investigator should be actuated only by his ambition and his investigations, or alone by his desire for exact abstract knowledge. If medical research is to be a vitalizing, reforming, uplifting factor, not only for the practise of medicine, but for the good of the community at large, then the whole man must be interested, heart and soul, not only in the technical and abstract results of his problems, but in their practical applications to medical and social conditions. What does this mean for medical research? That the laboratory shall be not only the brains, but the hands, of the community! It must recognize not only the problems of the community, but, solving the technical aspects of these problems, must demonstrate how they are to be met and cared for. In short, the investigator in medicine must be stirred by not only an abstract interest in human ills, but a direct interest in the problems, prophylactic or therapeutic, hygienic or social, of the community, with all its differen-

tiation into industrial, commercial and domestic activites, of which he is a member.

If I am right concerning the importance of these various influences it would appear safe to conclude that progress in medicine may be expected in the future, as in the past fifty years, through the opportunities afforded the well-trained individual in well-equipped and well-organized laboratories, through the cultivation of the methods of auxiliary sciences and through the ideal of social service. And here I may say that in using the term "laboratory" I do not limit the term to the ordinary sense, but include the idea of research work in the hospital. One of the great influences of the application of the laboratory idea to medicine has been the recognition of the principle that hospitals should be utilized not only for the care of the sick, which is the first and most important function of a hospital, but for purposes of teaching and investigation as well. With such a conception, a hospital becomes the laboratory of the science of clinical medicine and in it the clinician as an investigator studies disease by the same exact methods as are utilized in any other laboratory.

If, then, the laboratory and the hospital are the tangible means of progress in medicine which our universities offer, how may research in the university be best served and what advantage does the university gain by fostering research?

By limiting the scope of this discussion to the university I do not wish it to be thought that I desire to minimize the importance of the work done by independent institutions for research or by state and city laboratories. The important work done by the Rockefeller Institute for Medical Research, for example, has placed this institution in one group with the Pasteur Institute, Koch's Institute in Berlin, Ehrlich's Institute in Frankfort and the Imperial Institute for Experimental Medicine in St. Petersburg. The character of its present staff, including as it does, your former professor of physiology, promises as great work for the future as has been accomplished in the past. Likewise, the Memorial Institute for Infectious Diseases in Chicago and the Henry Phipps Institute of Philadelphia are doing valuable work in the study of the diseases for the investigation of which they were founded. Such institutions point the lesson of the economic importance of research, which, if fully grasped by the public, would guarantee the support of independent institutions in every large center or wherever special facilities for the study of particular diseases could be found. Moreover, all these institutions have recognized the necessity of an intimate connection with a hospital in order to render their investigations most effective.

So also laboratories of state or city departments of health as of the state of Massachusetts and the state and city of New York and the Hygienic Laboratory of the Public Health and Marine Hospital Service,

supported by the national government, have made original investigation of the infectious diseases an important and often major part of their work. In addition the Hygienic Laboratory has made most important investigations in pharmacology. Other non-university research institutions, as the New York State Laboratory for the investigation of cancer, the Rockefeller Commission for the Study of Hook-worm Disease, Trudeau's laboratory at Saranac for the study of tuberculosis and that for the study of problems of nutrition supported by the Carnegie Institution at Boston, are of great importance. Such institutions, and I have not exhausted the list, devoted to the investigaion of the problems of medicine and without affiliation with teaching institutions must be counted as among the most important factors in our social system.

Research in the medical school or the hospital, on the other hand, has developed slowly and has been in most institutions a matter of secondary importance. The reason for this is not difficult of demonstration when one remembers that even schools of university rank emerged only a short time ago from the proprietary state and that most physicians just past middle age can remember the two- and three-year course. Large classes, the belief in the didactic lectures, and the expense of laboratory equipment retarded the development of proper laboratory facilities and therefore the development of men trained to exact methods in the medical sciences. Likewise in the clinic the ideal teacher, with a few notable exceptions, was the busy consultant who devoted only a few hours of oratorical effort to clinical instruction and who disdained investigation as beneath the notice of a practical physician—an ideal which still holds in many of the more conservative schools and is responsible for the slow progress in the development of a science of clinical medicine. This type, however, is rapidly passing away and another generation may look back upon it as we do upon the age of the proprietary school, the two years' course and the amphitheater lecture.

It is not my intention to trace the beginnings of research in medical laboratories in this country, or, fascinating as it would be, if time allowed, to analyze early conditions and influences. A few men, however, stand out prominently, as, for example, Leidy, of Pennsylvania, teacher of anatomy and investigator in comparative anatomy, one of the greatest of American investigators in general biology, and Bowditch, who offered at Harvard in the seventies the first opportunity for organized research in physiology in this country. Laboratories of anatomy, that is, dissecting rooms, had always existed, but the modern type of anatomical investigation in anatomy is due to the influence of Minot, of Harvard, and Mall, of Hopkins. Likewise, laboratories of inorganic chemistry and so-called medical chemistry existed, but research in physiological and biological chemistry goes back only to Chittenden, of

Yale, and Macallum, of Toronto; Delafield, Welch and Prudden in New York and Fitz in Boston appear to have been among the first to control university laboratories of pathology in which at least a few men gave much of their time to teaching or investigation, but the great impetus to research in pathology and bacteriology coincides with Welch's affiliation with the Johns Hopkins Hospital, and experimental pathology as a sustained effort was first broadly cultivated by Flexner. Investigation in pharmacology by modern exact methods, in laboratories devoted to that subject, is the result of the labors of Wood at Pennsylvania, of Cushny at Ann Arbor, of Abel at Baltimore, of Herter in New York and of Sollman in Cleveland. The first university institute of hygiene was that established at Pennsylvania in 1892. These are the names which the compiler of American medical history one hundred years from now will compare, in discussing the development of our laboratories, with those of the period of 1820 to 1860 in Germany. Why? Because these men established not merely teaching laboratories, but stimulated investigation, inculcated exact methods and trained men, and thus made an impression upon the medicine of their time. This is true not merely of their influence in furthering research, but of their influence in advancing the fundamental principles of proper medical education. As soon as it was demonstrated that laboratories were indispensable to proper medical education, the day of the medical school worthy of university rank arrived and the proprietary medical school as an important factor in medical education became a thing of the past. Moreover, as I have intimated, the principle of laboratory instruction and laboratory research which gave to laboratory effort the strongest place in the curriculum has had a distinct effect on the clinical teaching of medicine and surgery, so that in some of our better schools the individual student now has that opportunity for immediate contact with the patient which allows the direct exercise of his powers of observation, of the use of instruments of precision and of exact procedures which assure the acquirement not only of knowledge, but power to obtain knowledge. The result is the recognition of the clinic as a place for the exercise of exact methods in the teaching of the clinical branches and in the investigation of disease. Both fields of activity, the hospital and the laboratory, now have the "common purpose to advance medical knowledge and thereby bring healing to the nations."

With this conception of a common purpose guiding medical education and medical research and with the present unanimity of opinion concerning the absolute necessity of control of a hospital by the university, the duty of the latter to research is clear. If the purpose of the machinery of medical education is to "bring healing to the nations"; if "the business of medicine is to get people out of difficulties through the application of science and dexterity manual and psychical" (Cabot),

then it is the duty of the university not only to teach known principles and methods, but to advance knowledge and methods by research.

It is futile to say that it is sufficient to teach and to utilize known methods for freeing peoples from difficulties, for the mere statement of such an attitude implies that an obligation exists to extend known methods or invent new ones in the hope of overcoming difficulties, acknowledged to be at present without remedy. The ethical force of this statement can not be denied. To teach a subject implies the attempt to diffuse the available knowledge of that particular subject matter among a number of people for their good as well as for the good of the community in which they live and work; equally true it is that such an attempt to teach available knowledge imposes upon the teacher the obligation to leave untried no means by which the knowledge of his subject may be increased. It is not the privilege of the teacher to leave this extension of knowledge to others. His profession of ability to teach a particular subject carries with it his obligation to the group or community he serves, of adding to his subject, knowledge of which they may avail themselves. If this applies to the individual teacher, how much more forcibly does it apply to the university with its ever-widening community and ever-increasing interests?

But ethics are frequently set aside in our practical, every-day world and even if they are not the great expense of maintaining laboratories and a hospital, an expense greatly increased if research is properly prosecuted, causes university presidents and trustees to ask what are the practical advantages of research to the university; and in those institutions which are supported, in part or entirely, by the state, this question must be squarely met.

In presenting the arguments in favor of research in the university, I will consider only conditions in this country and will not, though it would greatly strengthen the argument, utilize the experience of the German universities. One of the most important advantages, and one which should appeal to those controlling the policy of a university, is the influence on the student.

If one examines courses in the same subject in a number of schools, it is found that those which are best presented are under the control of men actively engaged in research work. Such men are alive to the advantages of new methods in their own subject and of new ways of applying old methods. Ever thinking and pondering about methods of acquiring new knowledge for themselves and their science, they appreciate better than does the non-investigator that which will aid the student to acquire knowledge, and in their teaching they bring to bear on the problems which the student has to face the same methods of attack which they use in their own researches. Under these men are assistants of the same point of view, who, ever enthusiastic about their

duties as teachers, nevertheless find time for research. And it is of further interest that in these departments assistants do not long continue in a subordinate place, or at least if they do it is of their own desire, for they are early called to independent positions in other institutions. On the other hand, one finds that the men who confine their teaching to perfunctory routine laboratory courses, with a profusion of lectures, are the men who never or only occasionally contribute to the literature of their science.

In these departments, too, the teaching is a routine which, so the assistants say, gives no time for investigation; and so they remain assistants indefinitely. So, likewise, it is with the student taught under these two conditions. The student who knows that he is working in a department actively emphasizing new methods and striving to develop new truths, knows that his instruction is presented on the same basis, and thus receives that stimulus and inspiration which ensures his approaching clinical medicine with a proper appreciation of the scientific method. The student under the method of the non-investigator, on the contrary, has no incentive other than that of acquiring a knowledge sufficient to allow him to pass an examination.

An allied argument lies in the fact that the medical school that fosters research attracts the best-trained men as students. We have, as is well known to many of you, a medical school in this country which has, for several years, arbitrarily selected from a large number of prospective matriculants the certain definite number which it desires; the rest, sometimes equal to 50 per cent. of those accepted, go elsewhere. Now this school has the highest of entrance requirements and perhaps the smallest alumni body of any prominent school in the country. It is not therefore a question of easy entrance or of the loyal influence of alumni. Nor is it a question of better laboratory and hospital facilities, for other schools have equally good equipment in both respects. Likewise it is not a question of geographic location or center of population. The enviable position of this school is due solely to the policy of combining research with teaching and of appointing to its staff teachers who, with few exceptions, are also investigators.

My contention that research in the medical school has important practical advantages to the university is, therefore, not visionary or theoretical. A policy which attracts the better-trained class of students, which improves the character of the instruction, which stimulates the student to a better type of individual effort, and which enhances the standing of the university in the community and the nation is a policy which can not be ignored by university president, trustees or faculty.

Another phase of this subject is the duty of the university in public health and other medical matters of interest to the community and essential to its welfare. State and city have always felt at liberty to

call university experts to their aid in the solution of problems of administrative policy and public weal. Not infrequently, as in the case of Harvard University and the Massachusetts State Department of Health and that of New York City and New York University, the university shares with the state or city the service of expert investigators in the preparation of curative sera and the study of new methods of combating disease. In some states the university laboratories of hygiene, bacteriology or pathology are the research laboratories of the state. The problems of agriculture, of animal industry and veterinary medicine are, in the states of the middle west, largely under the control of university laboratories. It is not my desire to discuss in its general application the question of the part of the university in social service but that the mid-western state universities have solved this question in the matter of animal and plant disease and in agricultural and certain industrial problems is evident from the occasional references to the university as "the people's organized instrument of research" or "the scientific adviser of the state." This idea of social service must, and already does, to some extent, include the study of diseases of man. To what extent the latter shall develop in state universities depends upon the liberality of the state, or, as in non-state universities, upon endowment by individuals. This matter of endowment is the crux of the research problem in its connection with the university. It is no longer possible for a medical school to be supported by the fees of its students. In the old days of the proprietary school, when instruction was almost entirely didactic, and the only laboratory work was the dissecting room, with perhaps a room for workers in inorganic chemistry and the simple procedures of so-called medical chemistry, fees sufficed and the faculty could pocket a good dividend. The increased cost of laboratory instruction in its many phases, the increase of equipment, of assistants and attendants, have made this impossible and have forced the medical schools to the shelter of universities which have resources sufficient to support medicine. But even with this aid, few schools have sufficient funds to satisfy the demands of adequate instruction and leave a balance for investigation. The result has been that universities seek special endowment for specific lines of investigation and it is unquestionably along such special lines that an increase in the facilities for research is to be expected.

A consideration of the special departments of research now existing, of the factors determining their establishment, and of the influence such departments have exerted may be worth while. It has been said by some authority on university affairs, that "the best way to get endowment is to deserve it"; and this is the principle which actuates a not inconsiderable body of men scattered over this country who by their efforts are attempting to bring forcibly before the public and

university trustees the value of investigation, particularly of the preventable diseases, as a necessary and dignified type of university effort.

It is of interest to note the various ways in which research chairs or departments have been established. Some have been the result of the multiplication of chairs devoted to one general subject, as at Harvard, which has in the medical school chairs of comparative pathology, comparative physiology and comparative anatomy, each of which is quite distinct from the chairs responsible for the fundamental undergraduate instruction in pathology, physiology and anatomy. The establishment of these chairs, in part through special endowment, has greatly increased the facilities and time available for research in these fundamental branches and for special or more detailed instruction in the various activities which they represent. Likewise the splitting off from bacteriology of independent departments of preventive medicine (Harvard and Washington universities) has increased the opportunities for the study not only of the infectious diseases, but also of those due to industrial conditions, to poverty and insufficient methods of preparing and handling food-stuffs.

Of similar origin are the departments established recently at Pennsylvania and Tulane for the study of tropical diseases. So also at Harvard an opportunity for similar effort has been made possible through the endowment of a traveling professorship in the department of bacteriology. In the same way increased facilities for investigation in chemistry has been brought about by the founding of departments devoted to physiological chemistry, independent of the older chairs of chemistry and toxicology; by the recognition of a sphere of usefulness in experimental pharmacology independent of materia medica and applied therapeutics; by departments of experimental pathology and pathological physiology, neuro-pathology and surgical pathology cooperating with or independent of the traditional departments of pathology; by the evolution in surgical teaching and research of laboratories of experimental and veterinary surgery, and, in our hospitals, of laboratories of clinical pathology. These departments, in most instances, having some instructorial duties, have an enormous influence in furthering research and in indicating the need for its extension. For the most part, whether founded on special endowment or otherwise, they are the result of an influence from within, the desire of the university authorities to increase opportunities for investigation and to improve facilities for teaching. Both these objects have been attained, and the success of many of these laboratories is a most potent argument in favor of increased endowment.

That such efforts are beginning to yield fruit, that the public is awakening to the importance of endowing research in medicine and is bringing to bear an influence from without, is shown by the increasing number of gifts, often spontaneous, for the support of investigation

under the control of the university. Many of these have been made with definite specifications as to the problems to be studied, which is encouraging evidence of a special study on the part of the donors and of a keen appreciation on their part of the limitations of medical knowledge and of the need of enlarging its boundaries. Of departments thus founded, some of the best examples are those at Harvard,[3] Cornell[4] and Columbia[5] for the study of cancer, the Henry Phipps Institute and Hospital, now a part of the University of Pennsylvania, for the study and treatment of tuberculosis; the department of experimental medicine at Western Reserve; the department of research medicine at Pennsylvania for the study of chronic diseases, the recently founded Sprague Memorial Institute affiliated with the University of Chicago for the study of the general problems of medicine and that recently announced by Northwestern University for the study of tuberculosis and other infectious diseases. Here also should be included the Wistar Institute of Anatomy at Pennsylvania, the work of which at present is devoted largely to research in problems of the nervous system.

Of special interest in connection with many of these foundations is the provision for investigation in the hospital in connection with laboratory work. Thus the foundation for the investigation of cancer at Harvard has its own hospital, the Phipps Institute at Philadelphia provides for the laboratory and clinical study of tuberculosis, the new Sprague Institute of Chicago has a hospital affiliation, the plans for the Memorial Institute for Infectious Diseases include a hospital for the study of such diseases, and some of the smaller foundations have been established with the understanding that the university shall ensure access to the wards of the hospital under its control. Surely the universities through the endowment of medical research will have opened to them invaluable opportunities for service not only in the investigation of special diseases, but in the broader field of the relation of social conditions to disease. In connection with the latter Dr. Richard C. Cabot has called the attention of the profession and hospital authorities most forcibly to their duty and to the opportunity for special research which this field offers. Already the Rockefeller Commission for the Study of Hook-worm Disease has undertaken the study of social conditions determining the occurrence of hook-worm disease and the University of Pennsylvania, by establishing, in connection with the Phipps Institute, a department for the sociologic study of tuberculosis, offers the first instance of a university uniting laboratory, clinical and sociologic methods in an effort to elucidate the problems of a single disease. The experiment is an important one in that union of effort in the study of a single disease, if based on the principle of social serv-

[3] Caroline Brewer Croft Fund Cancer Commission.

[4] Collis P. Huntington Fund for Cancer Research.

[5] George Crocker Special Research Fund.

ice as illustrated by the work and writings of Cabot, promises to give to university research a new field of activity; to medicine a powerful ally; and to society, an ideal of great promise for the good of the community.

To these various influences which I have presented at some length, we may, I believe, ascribe what little advance has been made in university research in medicine in this country. The same influences will continue to operate. The breaking down of the hard and fast lines which were drawn originally around the institutes of medicine will continue. As in the past, so in the future, the formation of new departments from the older departments will limit the field to be cultivated by a single individual and thus the time devoted to teaching a single subject will be divided, and as a result more time and opportunity for productive investigation will be allowed. Already immunology clamors to be released from alliance with bacteriology, hygiene or pathology; protozoology claims a domain distinct from that of bacteriology; pathological physiology demands greater recognition; and a new field—experimental therapeutics—distinct from pharmacology, is already well defined; all such expansions mean greater freedom and greater opportunity for investigation. These tendencies and the closely allied factor, the increased recognition of the hospital as a place for research (and especially the planning of groups of special hospitals, as at the Harvard Medical School), represent the forces within the university which have made progress possible. Of the forces from without which exert an influence, one, already discussed, is endowment for special investigation. A second is the influence exerted by independent institutions for research, as the Rockefeller Institute and Hospital, which by its magnificent work has stimulated the better university schools to greater effort in the advancement of medical knowledge.

A third factor is the demand of a gradually awakening public opinion that medicine should take a more prominent part, active and advisory, in the affairs of the community. The effect of this demand is already seen in the fact that the limitations and aloofness that characterized medicine in the past have already begun to disappear, and we can confidently look forward to a day when the activities of medicine, on its research and preventive sides, at least, will be—if I may so express it—imbedded in the social system, and shall live by and for it. In this connection, the university should not forget that the science of bacteriology and the knowledge which it has popularized concerning the etiology and control of disease and pestilence, formerly considered as foreordained and without remedy, has brought to the race a new hope concerning many of man's afflictions, and this hope is tinctured with an impatient demand that all preventable diseases, whether due to infection or occupation, should be thoroughly investigated. Preventive medicine has become a great educational movement, the onward sweep of which has been accelerated by modern views concerning the treat-

ment of tuberculosis, by municipal experience with the efficacy of water filtration against typhoid fever, the "cleaning up" in a hygienic sense of Havana during the American occupation, the wonderfully healthy state of the Canal Zone under Gorgas as compared with that in the time of the French control, the influence of a better understanding of the effect of hook-worm disease on social conditions in the south, and the importance of the destruction of the mosquito in the prevention of yellow fever and malaria. The public looks first, and naturally so, to its state and municipal laboratories for assistance, but it looks also to the laboratories and hospitals of the universities for that wise guidance and direction which, untrammeled by political expediency, is the result of impersonal scientific observation and experiment.

The problems which may be attacked by the university are both general and local; in many instances a most promising field of investigation lies at the university's door. As is pointed out in Abraham Flexner's Carnegie Report on Medical Education, the port of New Orleans offers to Tulane a great opportunity for the study of tropical diseases, and the industries of Pittsburgh offer to its university unusual material for the study of occupational diseases. The port of San Francisco, draining as it does the Orient, and soon to feel the influence of the Panama canal, offers to the university which will grasp it a field for the study of tropical and unusual imported diseases not open to any other city in the temperate zone. Industrial centers other than Pittsburgh offer advantages for the study of occupational diseases and the influence of industrial conditions. New York, Chicago and other large cities with compact populations present their own problems and even in sparsely settled rural districts arise questions of great importance.

So also every community has the problems connected with the diseases of infancy and of advancing years. The influence of bacteriology in focusing the attention of investigators and of the general public on the acute infectious diseases, though an influence of the greatest importance to medicine and one responsible for much of the endowment of research in this country, has had a tendency, on the other hand, to retard the study of diseases not due to bacteria or protozoa. The pendulum now, however, is swinging the other way, and the time has come to attack, with the aid of the methods of chemistry and physiology, the chronic diseases, the disturbances of metabolism and of internal secretion and the affections peculiar to infancy and old age. Only recently have the diseases of advanced life attracted an attention commensurate with their incidence and importance. As the fruits of the investigation of the acute infectious diseases have increased the expectancy of life by diminishing the mortality of infancy, childhood and early manhood, so the study of the chronic diseases incident to middle life and advancing years, should, by the determination of predisposing causes and methods of prevention, lead not only to a still greater stability of

life, but also, and what is more important, to a prolongation of years of useful activity and, perhaps, to a serene instead of painful final deletion.

This leads to the discussion of a new type of department in the medical school, departments or chairs for research only. That such departments are now necessary is the direct result of the unwise policy which, in the past, has led university presidents and medical faculties to appoint as heads of departments men who have little or no training as investigators and no interest in research. As the modern view of the duties of a medical school—teaching, the first duty, but investigation the corollary, essential not only for its own sake, but also for its influence on teaching—gains ground, university authorities find their chairs encumbered with men incapable and disinclined to conduct genuine university departments. New chairs, for research only, are therefore established in order to evade the penalty of a wrong policy and at the same time to secure men with the training and ideals of the investigator.

When university presidents learn that every professorship, clinical and otherwise, ought to be in some measure a research chair, and that research must be combined with teaching, the need for special departments of research will not be so urgent. It is true that clinical teachers are not united on this point; indeed, the weight of their opinion is often thrown in the opposite direction. For example, the anti-university conception of the university clinical professor has recently been very clearly presented by Professor Barker in an extremely plausible argument, in the course of which he proposes that two chairs should be created in the department of medicine—one for teaching and the financial prosperity of the incumbent, and the other for resarch! No more objectionable proposition from a university point of view has ever been made. Officially recognized and sanctioned separation of research from teaching, especially in the clinical chairs, would not only place the university on the level of the secondary school, but would delay all progress in medicine, and, more important still, destroy what little confidence the public is beginning to have in the altruism of university medical education. Let us hope that such counsels may not prevail. Let us work for the recognition of the principle that teaching and research should be combined in *every* department of the medical school. In the meantime, special departments of research may well be created, not only to make up for the sterility of the other chairs, but in order to attack problems that are of such magnitude and complexity that they may well engage the entire time of those devoted to them. But neither research professorships nor research institutes can ever relieve the professor of medicine or of surgery from the duty and obligation to continue to be creatively occupied in the development of their respective departments.

Existing departments of research are variously described as de-

partments of experimental pathology, experimental medicine or research medicine. The title matters little, but the plan of the department should be broad enough to care for the problems of clinical medicine, and for this reason the word "medicine" should appear in the title rather than the word "pathology." Such a department should keep in close touch with the department of clinical medicine, should supplement the facilities of the various hospital laboratories, and should also work in cooperation with the fundamental laboratory sciences in order to insure no loss of opportunity in the prosecution of its problems and thus a realization of the greatest good to the school. The head of the department should be a man familiar with the problems of clinical medicine, trained preferably as a pathologist, and with sufficient knowledge of the possibilities of physiology and chemistry to apply the methods of these subjects to clinical problems. I say preferably a pathologist because the pathologist is more apt to combine clinical training with a knowledge of pathology, bacteriology and the principles of immunity than is the physiologist, chemist or pharmacologist, though any one of the latter might well head such a department. Certain it is that whatever his own training may have been, the director should, with his assistants, be able to utilize in the work of the department the methods of physiology, chemistry, bacteriology and experimental pathology. In other words, he should have a department capable of attacking a problem in medicine from any or all sides, including that of experimental therapeutics; and in order to make the work effective, he should have the use of beds in the university hospital.

The work of this department should be the investigation of clinical problems, and not of academic problems of pathology, chemistry or physiology. General practitioners, clinical assistants in the school and even those at the head of clinical departments are constantly meeting problems which demand solution, but find no adequate opportunity to investigate them in departments as now constituted. These men would find a place in the department suggested and should constitute an enthusiastic working staff which should be exceedingly productive in the advance of medical knowledge.

I may be over-enthusiastic about this matter, but I believe that departments such as I have outlined are a necessary part of every large university medical school, and must be developed eventually through the combined efforts of the pathologist and the clinician, who have naturally a greater interest in the problems of disease than have the men of other departments and who must have a research department devoted to their common interests.

A department of this type, whether independent or affiliated with the chair of medicine, I would recommend to every university which sees its way to procure endowment for research in medicine, for in a department of such broad scope lies the possibility of attacking many

problems in the broadest way and of assuring the best utilization of endowment and the greatest good for the greatest number.

This discussion might be lengthened by the presentation of other phases of the subject of medical research, but I may well end with Mr. Eliot's all-inclusive characterization:

> Medical research habitually strives to arrive at something beyond abstract truth. It seeks to promote public and private safety and happiness, and the material welfare of society. Its devotees have in mind the discovery of means of remedying misery or warding off calamity; and they know that whatever contributes to health or longevity in any community or nation contributes to its industrial prosperity; so that they are justified in hoping for results from their work which will promote human welfare.

If my presentation of the subject of research in medicine. which now comes to its close, has any value it lies in an attempt to demonstrate two things: (1) That, wonderful as were the isolated achievements of the great discoverers in medicine in the early centuries, the great continuous advance in medicine during the past eighty years resulted from organized laboratory effort based on the principle of exact experimental methods, and (2) that it is the duty of the university so to organize its laboratories and hospital that this advance of medicine by research may continue, side by side with teaching, as a university function of benefit to student and faculty, as well as to the state and the general public welfare, and thus as an aid to the advancement of civilization.

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WIND-GRAVED MESAS AND THEIR MESSAGE

By Dr. CHARLES R. KEYES

DES MOINES

STRANGE and striking are the positive features of landscape presented by the continental divide in our southern arid country of New Mexico and Arizona. Wildest, least visited and most desolate section of our land is this, over which to-day still roams at will the aborigine in numbers greater for size of area than was ever known in any part of our realm since advent of European. Yet it was this very portion of our broad domain which was already settled by old-world men within fifty years after the landing of Columbus on Salvador. Before that time for more than twenty centuries there flourished within that region a peaceful and highly cultured race.

Throughout most of our desert lands the smooth illimitable plains are thickly studded by short, isolated, yet lofty mountain-ranges, which rise from the sea of earth as volcanic isles out of a glassy ocean. Desert-ranges form a distinctive mountain-type. As relief characters they attract wide attention from traveler and scientist alike, for they are the most impressive of the local features of topography.

In that part of the arid country of which we now speak there are none of these high mountains. The "Inselberglandschaft," as the Germans call it, still persists, but in different form. Instead of majestic peaks and lofty ranges there are lower truncated hills which rise even more abruptly from the general plains-surface. Mesas, or "tables," the Spanish-speaking settlers aptly denominate them. (Fig. 1.) The region is preeminently a mesa-land; therefore one of the most interesting and geologically one of the most instructive in all our domain.

That any part of a great continental divide should be a vast plain in place of a towering mountain ridge is primarily a result of geologic structure and secondarily of peculiarity of climate. In western New Mexico the broad plain occupying the divide is 7,000 feet above tide. So even is it that in crossing one is unaware of the time when he ceases to ascend on the Atlantic slope and begins to go down on the Pacific side. The ocean-to-ocean railway excavates its grade on the top of the continent only a scant half-dozen feet—one of the shallowest cuts on its entire line.

Mesas of the mesa-land impart to the landscape features entirely novel. Nowhere else on the face of the earth do they reach such notable

Fig. 1. Toyalane, near Luni Pueblo, New Mexico, a Lofty Plateau-plain of the Desert.

development. They appear as even-topped surfaces more or less well elevated above the general plains-surface about. The margins of these truncated mounds form the brow of a precipitous escarpment which is one of their most characteristic features. Not infrequently the upper part of the escarpment is a vertical wall 100, 200 or even 500 feet in height. Mesa de Maya (armored mesa) and Llano Estacado (walled plain) are Spanish descriptive terms referring especially to this feature. The talus-like slopes below are the steepest of any angle of repose; and their meeting with the general plains-surface is as sharp as the strand-line.

Mesa profiles and proportions are mainly functions of the geologic structure and of age. Some of these plateau-plains are so small in area and so high that they stand boldly out of the plain as conspicuous cones, or buttes. The Camaleon and Wagon-mound are illustrations. Others, as the Tooth of Time, the Enchanted Mesa (Fig. 2), the Covero, and the Sunset Tanks buttes are only a few acres in areal extent. The famous Toyalané (Fig. 1) and some of its neighbors are somewhat larger. From these to the great Chupadera Mesa and the Mesa Jumanes, which are a dozen miles across and a score of miles in length, or the vast Mesa de Maya, which extends along the northern border of New Mexico a hundred miles, there is every size.

Of the mesas of this description the foundation is generally some rock-layer more indurated than the rest of the section. Structurally they may be made up of (1) remnants of former plains worn out on the bevelled edges of folded strata, as in the case of the Mesa Jumanes; (2) slightly inclined strata of hard limestone or sandstone usually, which are intercalated in extensive beds of less resistant materials, as in the Chaca Mesa and other platform plains of the great Mesa Verde region; (3) almost horizontally disposed hard beds from which the soft superposed layers have been stripped, as the Toyalané, El Moro, the Tooth of Time (Fig. 3), and the Tucumcari; (4) old lava-sheets which cover soft shales and sandstones of which the Mesa de Maya, Mesa del Datil and Acoma Mesa (Fig. 4) are conspicuous examples (Fig. 5); and (5) surface-wash deposits locally hardened through the evaporation of moisture in the soil, leaving cemented lime-salts near the surface of the ground (Fig. 6), well represented by the Galisteo Ceja, south of Santa Fe.

The origin of most flat-topped hills is commonly ascribed to circumdenudation effects on an upraised peneplain. All remnants of the old graded surface are on the same level. Throughout the arid region the mesas or plateau-plains, which rise above the general plains-surface, also appear to be the direct result of circumdenudation, but of a very different kind. In marked contrast to the humid-land effects the remnantal plains of the desert, whether their surfaces be formed of stratum-

Fig. 2. Enchanted Mesa, in Western New Mexico; a High Remnantal Plateau of Small Area.

planes, beveled tables of flexed strata, lava-sheets, or cemented regolith, are of quite different elevations even in the same district. In New Mexico, for instance, these plains attain all altitudes above the general plains-surface, from a few feet in the case of the very recently formed Malagro malpais, in the Hueco bolson northeast of El Paso, to the broad Mesa de Maya which is 3,500 feet above the general plains-surface, and 9,000 feet above the sea-level. The Sierra del Datil in western New Mexico has a magnificent northward-facing escarpment 1,000 feet high; and in sight of it is the Acoma Mesa 500 feet above the plains-floor (Fig. 7).

Toyalané is a conspicuous flat-topped mountain situated just over the continental divide. The region is the largest, highest and driest desert plain in this country. Structurally and topographically it constitutes an essential section of the great Colorado dome, arching from the Rio Grande to the Rio Colorado. Save in one place—the Zuni Swell—its surface is unbroken by tectonic features. In this mesa-land

the plateau-plains stand at many different heights above the general plains-surface. To this particular great genetic significance is attached.

Several notable peculiarities distinguish the Colorado dome. Around its southern slope there is, as Gilbert observes, one of the great lava-tracts of the world, second in magnitude in our country only to the great northwestern lava-field, and fifteen times as large as the classical district of extinct volcanoes in central France. Sweeping in a broad crescent, 250 miles long, with the lofty cone of San Mateo on one horn and the towering San Francisco volcano on the other, the main body of lava-flows superposed in countless numbers, covers an area half the size of New York state. Beyond the borders of the crescent are numberless cinder-cones, coulèes, and minor lava-sheets which spread out over the soft sedimentaries constituting the chief substructure of the plains in this part of the country. Farther west, in Arizona, the hard carboniferous limestone is the principal surface-rock, the shales once overlying it having been recently stripped off. Other volcanic evidences

FIG. 3. TOOTH OF TIME, NEW ACOMA PUEBLO, NEW MEXICO. Last vest'ge of a once extensive plateau-plain.

are the denuded necks and dikes. These lava-sheets form the foundation of many a notable mesa.

Outside the limits of the lava-fields the massive and more indurated beds which are included between the thick sections of weaker strata take the place of the lava-flows in the formation of the mesas.

In the region under consideration extravasation of lavas has evidently gone on at frequent intervals from the very beginning of Tertiary times almost, it may be said, to within the memory of men still

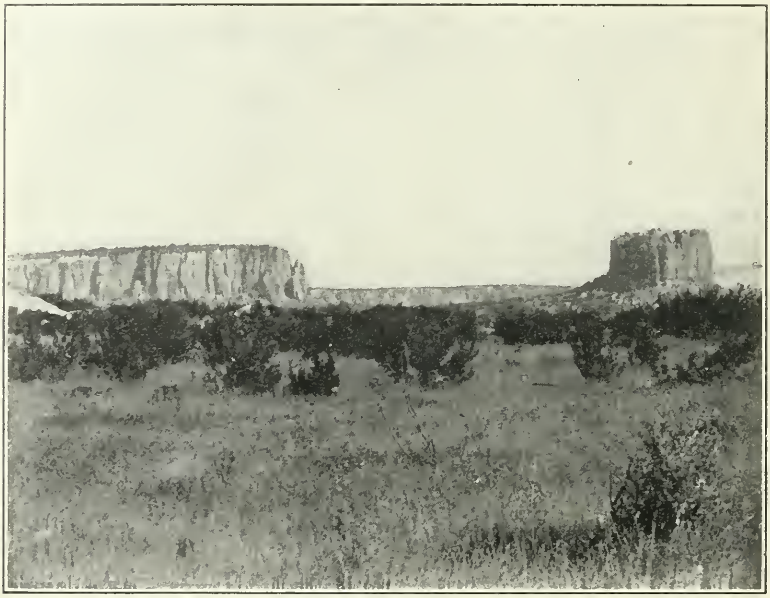

Fig. 4. Outliers of the Great Acoma Mesa. The plateau-plain is 500 ft. above the general plains surface.

living. The older trachytic and andesitic lava-sheet of the San Mateo, or Mt. Taylor district, now stand 1,000 feet above the country around, and upon this mesa rests the old volcanic cone itself, higher and more impressive than Vesuvius. To the north of this peak, which rises 13,000 feet above sea-level, there are abundant evidences of still earlier volcanic activities as shown in the forest of volcanic-necks of that area, from which is swept almost every vestige of their cones and the plains upon which they stood (Fig. 8). Cabazon, a huge volcanic pipe, stands 1,200 feet above its base and is a landmark for eighty miles about.

Much younger and 500 feet below the San Mateo plain is Acoma mesa, 30 miles long and 15 miles wide, capped by basalt. At its foot, another 500 feet down, is a great basaltic flow, 50 miles long by 20 miles broad, covering the present plains-surface. Even more recent are

the coulèes from the Tintero, on the Mesa Redonda, west of the San Mateo, that finally enter the channel of the Rio San José at a level considerably below that of the great flow already mentioned.

Four distinct and notable periods of volcanic extravasation are thus recorded, between the first and last flows of which more than 1,000 feet of rock were removed from the entire region about. There are in the district many other lava-flows at other elevations; but between the four especially mentioned definite time-relations are readily established.

At the present time particular interest attaches to the mesas and their origin. Normal water-corrasion manifestly did not accomplish

Fig. 5. A Lofty Isolated Mesa near Acoma Pueblo; capped by Lava and a Hard Sandstone Stratum.

the strange sculpturing of the country. In these relief features we seem to be introduced to an erosive force as potent as water but which we are just beginning fully to appreciate. Mesas appear to furnish the most direct and convincing testimony we have of the tremendous power of the wind in affecting general erosion under conditions of aridity.

That water could not possibly produce such effects is shown in a number of ways. On the continental divide the streams are their smallest. On a vast plain so situated drainage features are necessarily insignificant. Rainfall is the scantiest. These three conditions combined with arid climate give water-action small opportunity to vigorously erode. On every hand the country clearly shows it. It is equally

Fig. 6. Tilted and Beveled Cretacic Sandstone, overlain by Cemented Horizontal Breccia, near Los Cerrillos. New Mexico.

manifest that notable leveling and lowering has gone on at a rapid rate. Since the San Mateo and Datil plains-surfaces were flooded with lava vast degradation has taken place.

Extensive erosion is everywhere manifest but of peculiar type. There is little of the sharp incision of the plains-surface such as normally characterizes stream-action, especially in a high-lying region having slopes of high gradients. Erosion is of the broad-basin type—wide, flat-bottomed, even plains between abruptly upturned rims against resistant rock-masses. As the lava-flows and coulèes became more and more numerous the separate basins became divided and smaller, but general lowering of surface went on without interruption. There can be no question but that the lava-capped mesas at varying heights represent former levels of the general plains-surface.

In the outpouring of the molten rock over the surface of the plains the lava-streams naturally flowed down the lowest lines of the plains, but as removal of the weaker beds on either side took place each flow was soon left as an elevation. A particularly instructive instance is shown near the Zuñi pueblo, where an old valley is exposed in a section filled with basalt, the level of the latter in the mesa-face being several hundred feet above the present floor of the plain.

There is further strong evidence of the strictly eolic nature of the landscape sculpturing. These summit plains of the continent are a

region of continual high wind and constant sand-storm. Nowhere else in the arid region of the southwest is wind-scour in active operation so advantageously viewed. Nowhere else in this country are deflative effects and desert-leveling so well displayed. Nowhere else in all the world is general lowering of an elevated country by the winds so strikingly presented. Few places there are on this continent where stream-action as a general erosional power is so manifestly utterly impotent.

That this high, dry, almost waterless waste on the continental divide should owe its landscape features chiefly to the incessant blowing away of the dry pulverulent soils seems to need little argument in this place. In the case of a desert district where the rocks alternate in hard and soft strata a mesa capped by a more indurated layer might not always offer conclusive evidence in support of this contention. Against the mesas surfaced by lava-sheets of diverse ages such objections can not be raised.

The existence of desert mesas whose surfaces stand at many different levels throughout the broad belts of the less resistant rocks appears to furnish one of the strongest proofs of the eolic character of the regional erosional activities; since in situations of this kind not only are rainfall and water-action very deficient and wholly inadequate to produce the relief effects presented without the time-element be vastly and unreasonably prolonged, but conditions are such in many cases as absolutely to preclude the intervention of stream-work.

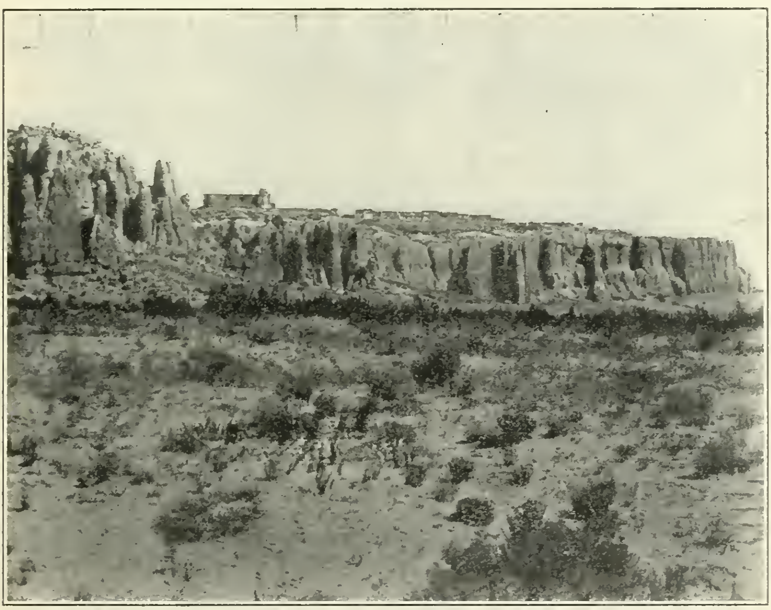

FIG. 7. FACE OF THE HIGH ACOMA MESA. The Acoma Pueblo is shown on the summit.

Fig. 8. Forest of Denuded Volcanic Rocks, which penetrate Soft Sandstone Strata; Northeast of San Mateo, New Mexico.

By wind-action alone there appears now to be incontestable testimony that from the entire area of the vast arid region there has been lifted and exported by the winds in very recent geologic times a prodigious layer of rock not less than 5,000 feet in thickness. With a continuance of the present climatic conditions another volume of rock-materials of equal dimensions seems allotted to be similarly transported before the effects of the process shall become appreciably diminished.

Thus it is that the arid regions have introduced to us an erosive agent more potent than stream-corrasion, more constant than the washings of the rains, more extensive and persistent than the encroachments of the sea. The present conception of general eolic erosion, a sculpturing power in every way comparable to erosion by river and by ocean, appears destined to take its place among the first half-dozen great and new thoughts which shall especially distinguish geologic science of the twentieth century.

OLD LAMPS FOR NEW

By JOHN MILLS

NEW YORK CITY

THE lament for the good old days, which rises so frequently from academic circles, has recently in the case of Amherst College resulted in definite action and policy. Following the recommendations of a group of alumni of the eighties, Amherst has reacted against the commercial and technical tendency of modern education, and hereafter is to be wholly and frankly classical in its aims and its curriculum. Whether the hands of this particular college clock can be turned backward without injury to the works, or false guidance to the youths whose period of training it apportions, is a question for the future. That something is amiss in our present scheme of higher education, and that the unassisted processes of evolution will lead too tardily and expensively to a solution is, however, the feeling of many.

The form of the lament and the burden of its criticism depend upon the early training and business or professional experience of the critic, and upon his business or social relations with present-day college graduates. One critic attributes his own personal success to the study of Latin and Greek, another to the course in "moral and physical philosophy" pursued under his college president, and a third finds his intimations of immortality in the mathematical concept of an infinite series. But one and all, in final analysis, agree that the college prepares for no special vocation, and the technical school for a too special vocation.

The failure of the technical school is not due to the over-specialization of the doctor of philosophy or German-trained research student. The average doctor of philosophy can at least think in the terms of his own narrow division of the world's knowledge, whether he is gifted with scientific imagination or not. The average technical school graduate is a Tomlinson of the laboratories and text-books, a product of modern motion study, who can perform certain laboratory manœuvers or calculations with a minimum expenditure of mental energy. These various operations are listed in the school catalogue and referred to in the diploma. The better the name of the institution, the greater surety does it offer to the captain of industry who buys its wares that they will meet the specifications.

In part, this unfortunate condition has resulted from the short-

sightedness of that large majority of employers who for years have required from the engineers they employ not broad training and scientific capacities, but a facility in the particular operative requirements of their industries. In part, this condition has arisen from the competition of technical schools for students, and the resulting tacit commercial agreement between institution and student that each graduate shall be found his first employment. Thus an institution chooses the heads of its departments, as far as its finances allow, not for teaching ability, but for influential acquaintanceship with men of affairs. To place the average of its product it must train for immediate usefulness. There results a number of attendant and contributory evils, such as shop methods of instruction by an inbred teaching staff, the detailed following year after year of the same outlines for courses, the performance of laboratory work as an end instead of as a means of encouraging analysis and vivifying principles, an over-emphasis of draughting and machine shop work, the construction by classes of dynamos and steam engines as advertising evidence of technical proficiency, the steady cramming of formulæ and numerical values of physical constants, the narrowing commercialized outlook upon all problems of life, the lack of esprit de corps, and the more or less entire absence of cultural studies and influences. Such an arraignment can not hold against all our technical schools, but upon the whole the exceptions are not individual institutions, but their individual departments.

Whatever may be the faults of curriculum and educational policy to which the technical school student is subjected, he learns to work hard, consistently and with scientific honesty. Upon this gospel of hard work depend almost entirely his chances of future salvation and success. In the commercial world, however, many pockets and ruts await the man of narrow training and hard-working proclivities. From these pockets, to be found in any large manufacturing or operating industry, too frequently the technical school graduate fails to rise. In many cases native disabilities are to blame, but more frequently the narrowness of an early training is the fundamental cause. This narrowness of preparation may be analyzed generally into three defects.

First, and most seriously to be charged to the account of the technical schools, is the lack of scientific breadth and depth which has been previously mentioned. Upon too thin a layer of pure science and mathematics does the engineering school build its superstructure of commercial machines and technical processes. Too soon do empirical equations and shop rules take the place of mathematical analysis and *a priori* reasoning. Too soon does the laboratory work become an exercise in the operation of commercial machines under conditions which require of the student only the throwing of switches and the reading

of gauges and, later, the filling out of a printed blank form with the result of routine substitutions in formulæ. The obvious objection that there is not time in a technical course for a broader preparation and the existing superstructure is admitted, but it is to be met categorically by omitting the superstructure which can be easily supplied under commercial conditions by our industrial companies.

In the senior year, some time is spent on minor questions of the cost of engineering work. The larger question of costs, the whole field of modern economics, is in general passed by or alluded to in a brief introductory courses. In a day of economic questions, so many of which have direct connection with engineering, this failure to train the future engineer to assist in their solution is the second defect in the technical school. Many problems, such as those of public utility rates, of the conservation of natural resources, of the protection of workmen from industrial accidents, and of sanitation and transportation in cities, must ultimately be solved in conjunction with engineers. Men trained in the fundamentals of economics, possessing a knowledge of the economic history of our country, who are in touch with the practical engineering or commercial aspects, may be powerful forces for the public good. This second defect may be remedied by the student after graduation, but in the manner of human nature the chances are small that it will be.

The first defect limits the chances of success of the individual, the second more especially limits his value to society, and the third will be seen to determine to a large extent his social relations. The hours of the technical student are closely filled with laboratory, shop and draughting exercises, with classes and periods of study. His opportunity for acquiring social conventions and amenities are necessarily very limited, and, unlike the arts-college man of more leisure, the end of his course finds him but slightly changed by attrition with his comrades. While such training is not essential to the student who is favored with a socially alert family, upon the unfavored and favored alike the technical school imposes its third defect, by surrounding them with an atmosphere essentially devoid of all cultural interests of music, art, literature, or drama. The average technical-school graduate may be justly accused of being deficient in sympathetic points of contact with his fellow man. He is prepared for a too special vocation.

In regarding, upon the other hand, the arts colleges it is well, momentarily, to eliminate from the consideration those students to whom such an institution is but an intermediate step to medical, law, divinity, or technical schools, and to consider the normal college man whose days of study end with his graduation. There must also be eliminated all those whose college course is essentially a professional course, namely, those preparing to teach, whether or not their early intentions are toward graduate study. There remains the future states-

men, artists, executives or business men, to whom the college offers four years of broad cultural training, new points of view, and contact through literature with the best of the world's thought. Such a student is prepared by these four years for no special vocation, and perhaps not so well for any vocation as if the training had been for some special end.

The strong-minded and mature student appears the exception to this statement, but in general will be found to be pursuing a self-imposed curriculum with a definite vocation in mind. The prospective ministers, lawyers, doctors and teachers were excluded from consideration because their college course is not necessarily a broadly cultural one, but a selected vocational training. For the same reason must the mature student be excluded. A college instructor can separate his class into three groups, those who set the pace, those who follow, and those who fall. Of the first two groups some few are "grinds," some few "out for honors," and the rest with rare exceptions interested vocationally in the subject-matter. In every class prospective teachers help to set the pace; in English courses, writers; in biological courses, doctors; in chemistry, manufacturers. In other words, for the average students there is no broad cultural college course, but rather many individual vocational courses.

The essential differences, however, between the vocational college course and the technical-school course are both of degree and of kind. The difference in degree is due largely to the existence on the one side of a fixed required curriculum and on the other of a free or group elective system. In a fixed engineering curriculum are many closely related courses, those of one school year being immediately prerequisite to those of the next year. In the better and larger technical schools a failure in a prerequisite course, besides calling for a repetition of the course, prevents the progress of a student with his class and delays graduation one year. In arts colleges, under an elective system, the severe penalty of a year's delay in graduation need only occur in case the failure takes place in the last term of the senior year. Given students working under these two systems, beneath equally eager and requiring instructors, the pace of the average in the technical school will exceed that of the average in the colleges. The result of this difference reacts upon the atmosphere of the institutions and leads to cumulative effects. Thus in recent years athletics, as well as many other school diversions, have steadily decreased in prominence in technical schools and increased in colleges. This decrease in engineering schools has resulted in more time and energy for study and admitted of a still harder pace, while in arts colleges the increase has diverted the students' energies and slowed the class room pace.

A further difference in degree resulting from the close correlation of courses mentioned above may best be shown by illustration. Mathe-

matics enters more or less into every engineering curriculum. Consider as an example that of the electrical engineer. Differential equations are frequently met in the study of electricity, and hence a mathematical course in this subject is a prerequisite. The sequence of subjects immediately prerequisite to this study, given in descending order, is integral calculus, differential calculus, analytical geometry, college algebra, trigonometry, solid geometry, plane geometry, elementary algebra and arithmetic. These are actual prerequisite courses and a study of differential equations requires a knowledge and ready facility in all of them. As commonly taught, and except for plane and solid geometry, there are few daily lesson assignments the subject matter of which does not enter directly into the later study of differential equations. The penalty for slip-shod work in the early courses is sure and cumulative. Consider, upon the other hand, the study in college of the books of Herodotus, the plays of Sophocles, or the orations of Demosthenes. Certain prerequisites are usually assigned by the Greek department, but the underlying idea is generally to prescribe sufficient elementary Greek to assure a homogeneous class with a fair facility in the language. Slipshod work in earlier courses does not bear so immediate and evident a penalty as in the case of differential equations. The entire omission of some prerequisite as Homer or certain dialogues of Plato would not seriously inconvenience a student. In fact, no particular day's lesson in most of the earlier courses may be said to be absolutely prerequisite.

Many illustrations similar to the one just cited are to be found in engineering curricula. A further illustration in arts may well be given. Thus consider history. A general introductory course in medieval and modern history is usually a prerequisite to further study. But later courses dealing with special periods as that of the French Revolution, do not demand so imperatively exact and complete preparation in the introductory courses.

The technical school, with its groups of continuous and interdependent courses, offers more severe mental discipline for the average student than does the arts college, where the prerequisites are largely formal requirements for the sake of a logical continuity that lays small burden on the student's mental powers. This is true even under a group elective system. Thus imagine a group requirement which called for four courses in the same scientific department. Biology offers general, introductory, and but slightly related courses in physiology, anatomy, botany and zoology. The disciplinary value of a general introductory course in any subject, which is not followed by a punishing and detailed study to which it is immediately prerequisite, is slightly more than that of a popular series of illustrated lectures with collateral reading.

The aphorism of pedagogy, "No impression without expression," may be extended to read "There is no enduring impression of an unused

truth." A truth of fact or method may be expressed in recitation and examination, but its impression frequently will not endure to graduation unless it has been reenforced by use in later and more advanced analysis.

The difference in kind between the vocational-college course and the technical course is esthetically in favor of the college. What is "shop" to the writer or artist is culture to the general, but what is shop to the engineer is shop to every one. Those subjects of a college curriculum which, unlike the sciences, are not shop, are to be classed popularly as either pedantic or cultural. The economic group is an illustration of the first division, the language and literature group of the other. The technical-school graduate, as has been noted, is sadly deficient in both divisions. The arts-college man pursuing his individual vocational course may be practically as deficient as the graduates of the better technical institutions. In general, however, he is not.

Some possible difficulties in the way of the Amherst scheme have been indicated by this analysis. To those students, whose individual vocational courses do not include the sciences, the Amherst curriculum will be essentially that of other colleges of the same rank. The attempt to supply a general broad culture and training for those students who have no definite objective, but are potentially future statesmen and administrators, seems to promise nothing more than do Harvard, Williams or Yale. Except for the students in vocational courses, however, the pacemakers will be gone. It is hard, as has been noted, to say of any day's class assignment of history, philosophy or language, that it is likely to be of service in later life. For the engineering, law or medical student, a statement of the probable usefulness of each particular lesson can be made with more certitude and definiteness; for other vocational students with less, but for the student of general culture, with a minimum. The question then is whether, in the distraction of interests, without a single and definite goal, lacking the disciplinary sciences, when of no single day's lesson it can be said that it is immediately prerequisite to the student's life work, the class-room standards will not suffer.

To place the emphasis upon the "humanities" is retrogressive if the term is defined in its limited, derived and Scottish meaning of "polite and classical literature." Let the term be defined by a less derived meaning of "liberal knowledge befitting man" and it may be postulated that college and technical school alike should train their students in the humanities. This liberal knowledge should fit a young man for service to society and for sympathetic and congenial relationships with his fellow man. It must include not only the history and economics and the cultural arts and literature in which the present technical course is deficient, but also the science in which too often the arts

college graduate is untrained. The position of science in present-day life needs no advocate.

It would seem that the difference between colleges and technical schools would then disappear. In part, this is true and is desirable. A difference of degree would still exist, as is evident from the following suggested changes in their respective curricula.

For the technical school there is suggested a standard five-year course embodying all the features of the present four-year standard, except some of the instruction in purely commercial operations. The resulting year and a fraction gained for further study would be expended in part upon pure science and mathematics, but largely upon history, economics and literature. The objections to such a curriculum are mostly in the nature of practical difficulties in its inception. The competition for students between technical schools is sufficient to forbid any except the largest and financially most secure from announcing to prospective students five years to accomplish a degree for which the purely technical requirements represent but four years' work. A large number of our technical-school students are so short-sighted that they resent and tend to avoid anything in the curriculum which does not seem to bear directly upon the degree and the job to which it admits them. Any instructor in English in a technical school can support this statement. The difficulties are then, on the one hand, short-sighted students, and on the other, short-sighted employers.

A technical school, however, should be distinctly above the grade of a business college or a school of stenography in its relations to the ultimate public welfare. It should exert a formative influence upon the future of its professions and not merely mirror existing commercial conditions. It should by precept and requirement lead the short-sighted members of its student body to a desire for a broader preparation, and, relying upon that increasing number of far-sighted employers to care for its graduates, it should confidently anticipate the market for its product.

For colleges, on the other hand, the following detailed suggestions may be made. First, that a general introductory course of a year's duration be required of the student in each of the subjects of physics, chemistry and biology. In biology the emphasis should be upon living forms and not on classification and nomenclature. Second, the student shall then elect one of these subjects for continuation. The character of these three subsequent courses departs radically from present college conventions. Each course should be of a year's duration and should treat briefly of the present-day commercial and technical applications of the principles studied in the introductory course. The aim should be to impart those scientific facts and methods of probable later value to the student either in business relations with scientists and engineers, in

questions of public welfare, in questions of investment, or in the pursuit of personal health and pleasure. Thus there would be studied such practical matters as the generation, distribution, metering and sale of gas and electricity; hydro-electric and irrigation developments; water and sewerage systems; heating and ventilation; illumination; sanitation and hygiene; the chemistry and physiology of foods; electric and steam traction; steam and gasoline engines for power or pleasure vehicles.

Such courses are quite possible if based upon introductory courses of sophomoric grade. The ordinary high-school courses do not supply a sufficiently advanced basis. The introductory courses should be especially outlined in connection with their continuations. The advanced courses would best be presented under the direction of three instructors broadly trained in their respective subjects of electrical engineering, chemical engineering and sanitary engineering, in cooperation with a doctor of medicine, an economic geologist, and the pure science instructors of biology, physics and chemistry. The work of all the courses should be of the same standard as that for similar subject matter in the best technical schools. The subjects should be presented by illustrated lectures, class recitations from text-book assignments, exercises in problems, excursions to illustratory industries or public improvements, and written reports. The success of such courses depends much upon the teaching staff. The need of some such courses, however, is steadily increasing.

In the main the solution of the present educational problem may be said to demand more liberal arts in technical schools, and equally, more practical science in colleges.

THE REVIVAL OF ECONOMIC ORTHODOXY

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TO the student of thought, it is interesting to see how long a theory persists after its foundations have been undermined. One can almost say of theories that, like superstitions, they never die. They have at least nine lives and are killed again and again before their adherents can give them up. And the worst of it is that disproved theories have an especial attraction for the best minds. It is not poor thinkers, but good ones, that try to square a circle or to create perpetual motion. Old thought is also well-formulated thought. It has a complete terminology and its shades of meaning can be expressed with accuracy. New thought must use terms that are unfamiliar to the public or are twisted somewhat from their popular meaning. A logical thinker let loose on a new topic can play havoc with the printed page of his opponent who has the facts but does not have the language to express his view. Only when one has tried to state some new thought does he realize how poor a vehicle language really is. He finds that most words are synonyms used to express old ideas in many ways. None of them are free from implications that turn the reader back to the older view instead of helping him to break new ground. New thought does not get into the printed page until long after it is a reality to those who study nature instead of books.

This statement has been provoked by an article entitled "A Bugbear to Reformers" in the May number of this magazine. If Professor Carver had put his article in an economic journal, his readers would understand what he has omitted or covered up. He choses, however, to appeal to a less specialized audience and talks in terms of analogies, instead of stating the economic facts. Reformers, he says, deny that water runs down hill. This kind of talk has a familiar ring. It is the way orthodox economists of a preceding age reasoned. They rarely stated or even knew the facts. They routed their opponents by a free use of analogies drawn from the physical sciences. While this sort of reasoning fell for a time into disrepute, it has of late shown a renewed vigor because some of the new economists have pushed so far ahead as to be on unstable ground. A reaction has set in and on the tide of the reverse movement some expect a return of the good old days when economists talked of the law of gravitation, the rise and fall of tides, the

equilibrium of physical forces and like analogies, instead of squaring their theories with the facts. This gives Professor Carver his chance to question the sanity of those who reject his favorite doctrines.

At first thought, scientists may favor a settlement of economic problems by the use of familiar ideas involving no economic knowledge, but in the end it will prove a mistake to appeal from adverse economic opinion to those versed in physical science. The orthodox economists were city people who let their imagination have free play in agriculture. One of their pictures was that of a vast plain of identical soil and climate. After picturing this world, they asked what motive can any one have to move from one part to another? To this Professor Carver replies, "whenever agricultural populations tend to spread, it is either a sign of insanity on their part or of diminishing returns on land."

To deny this, an economist does not have to pump water up hill. He questions the picture on which the law of diminishing returns is based. The principal that Professor Carver overlooks is the localization of soils, climates and products. The various geological deposits are irregularly placed and the climates found in different localities are even more diverse. Animal and plant life have been localized so that each locality yields different products or the same product at varying costs. No acre can yield as much return to labor as if it were spent on many acres or in many localities. Conversely, no race living on one article of food or using one kind of clothing or shelter can be as vigorous as those who supply themselves with a greater variety. The spread of population is due to this fact. The more climates, soils, animals and plants utilized, the better the living and the lower the costs.

A primitive community does not, as Professor Carver assumes, use a single soil and some one food. It is as complex as a modern state. The bottom land is used for plowing, the upland for grazing. There are wood lots, fishing places and an open region where wild game roams. Men go farther for goods in the modern than in a primitive world, but this does not imply diminishing return. When they herded sheep in an adjacent mountain valley, the effort then needed to get a pound of wool was greater than it now is to bring it from Australia. We have increased the distance traveled, but we have reduced the cost. Every spread of population has brought increasing returns because it has helped men to utilize the natural resources of the various localities. Is a community wise or foolish which uses different soils and climates instead of confining itself to one? Can two communities with different soils and climates exchange commodities to mutual advantage? If they can, there is a valid reason for the spread of population. Such a movement is not as insane as it seems to those who do not appreciate the localization of resources.

Professor Carver asks why England should not get all her agricul-

tural products from her own soil. The obvious answer could be found in any economic text-book. England has great stores of coal and iron, while other regions have none, or what they have is of inferior quality. This localization of resources makes an exchange of products advantageous, and in such an exchange the lighter and more easily moved products are transported. This fact has been greatly to the advantage of England. Food has come to her instead of coal, iron, cotton and wool going elsewhere to be worked up. This advantage is now lost and there is a spread of industry to other nations, much to the disadvantage of England. The pressure that is now producing so much poverty in England is not due to diminishing returns, but to a more natural distribution of industry. Another reason for the movement of food to England has been the unstable political conditions elsewhere. If Russia will not protect industry, her food goes to countries where it is favored. The diminishing returns thus caused are felt, not in England, but in Russia. England gains by trade with inferior nations and has her profits raised thereby. It is not England but the inferior nations that pay the cost of transportation.

Professor Carver asks why does urban population grow, and again answers—the law of diminishing returns. The real reply is that urban population grows because the scale of production is increasing. Centralized industry yields a greater return than localized workers receive. He also asks why it is necessary to change our habits, eating, for example, more oatmeal and less beef? In replying, he is as far off here as in his other answers. It is not the poor who cut down the amount of meat they eat. It is the more intelligent, and they do it because a varied diet gives them more energy. That the English eat beef and wheat bread is not due to their superiority as food, but to historical conditions. English habits are social survivals, not physiological necessities. The English eat meat for the same reasons that the Jews refuse pork. If these old dietary laws prove anything, it is that the law of diminishing returns is a social tradition and not a physical law. Why, he also asks, are inventions and improvements made unless it be to enable increasing populations to avoid the law of diminishing returns? Inventions are not made to support increasing population: population increases because inventions have been made. I can point to forty instances where the increase of population has followed inventions. I doubt if he can point to one where the increase of population came first. Growing population is an effect, not a cause. Men make improvements to increase their product. The economy of effort is a psychic tendency, not a physical fact. We get inventions as men move up in the scale of existence, not as they move down.

Two fundamental facts are thus involved in the relations of men to nature. The resources of the world are localized and population must

spread to utilize them. This natural spread is limited by the cost of transportation. On the other hand, the economy of effort demands the concentration of population. Inventions and large-scale production give advantages to centralized industry. When population does not spread, we may be sure that centralized production is overcoming the disadvantage of transporting goods. If X represents the cost of moving goods and Y the advantage of centralized production, the equation that results is $X < Y$, that is, the effort of moving goods from place to place is less than the advantages in production and consumption that such a movement brings. Greater returns, greater population and its wider distribution go together. The one society into which we are blending will utilize the world more fully than the many local societies of the past have done, and at the same time its members will be a multitude so vast that the underpopulation of the present can be readily seen.

GEORGE MARCGRAVE, THE FIRST STUDENT OF AMERICAN NATURAL HISTORY

By Dr. E. W. GUDGER

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"GEORGE MARCGRAVE[1] was born at Liebstadt in Saxony in 1610, went as physician with the expedition of Count Maurice of Nassau-Siegen to Brazil in 1638, wrote 'Historia Rerum Naturalium Brasiliæ' and died on the coast of Guinea in 1644." Such are the accounts, when divested of errors, given of Marcgrave in our biographical dictionaries.

However, the present writer, having had occasion to trace back to Marcgrave, as the original describer and figurer of the species or genus, three American fishes on whose life histories he has worked, has become somewhat acquainted with his career. Finding this of much interest, he has endeavored to collect the scattering data and has worked it into this sketch, hoping that other present-day students of natural history may also find it of interest to know something of this man who first of all essayed to make known to the old world the real natural history of the new. If in this sketch the present writer has helped to make Marcgrave's excellent work known, and to give him the recognition he justly deserves, he will feel abundantly repaid.

As the sequel will show, the material for a sketch of Marcgrave's life is scanty, widely scattered and hidden in little-known sources. Considerable time and effort have been spent during the past year in getting it together, but the amount of data would have been comparatively limited save for the help and cooperation of a number of librarians.[2]

[1] Also spelled Markgrave, Marggrave, Margrave, Markgraf, Marggraf, Marcgraf, but written by himself Marcgrave.

[2] The majority of the works cited have been consulted through the kind offices of Mr. Herbert Putnam, librarian, and Mr. W. W. Bishop, superintendent of the reading room of the Library of Congress. To Mr. Harry Clemons, reference librarian of the Princeton University Library, and to Mr. H. H. B. Meyer, chief bibliographer of the Library of Congress, the writer is indebted for many courtesies in matters of bibliography. To Mr. H. M. Lydenberg, reference librarian of the New York Public Library, his debt is great. Mr. Lydenberg has taken a personal interest in this work and has supplied data and references of which the writer would never have heard but for his kindness. He is likewise under especial obligations to Dr. Perlbach, of the Royal Library of Berlin, for photographs of the original drawings of Brazilian objects (hereinafterwards reproduced), for references and for copies of articles not procurable in America. For help in translating the large number of Latin references used, the writer is under obligation to Misses Boddie and Dameron, of the Latin department of this

Our knowledge of Marcgrave's early life is especially scanty, our most reliable and almost only authority being Manget or the unknown writer in his "Bibliotheca Scriptorum Medicorum," 1731, whose account the others probably copied.[3]

From him we learn that George Marcgrave was born September 10, 1610, at Liebstadt, a town of Meissen in upper Saxony. He came of a good family which had lived in Liebstadt for two hundred years. His father and his maternal grandfather were men well educated for that time, being "learned in theology and in Latin and Greek."

These men, seeing that Marcgrave was a boy of fine character and great promise, seem to have devoted much time and attention to his education. They taught him Latin and Greek and saw to it that his talents in music and painting were developed, so that he turned out to be no mean musician and "a painter not to be contemned." These same wise parents seeing that, if Marcgrave would ever do anything in the world, he must get out into the world, exhorted him to travel and study, and he, nothing loth, set out in 1627 in the seventeenth year of his life, and did not return to the paternal roof for eleven years.

During this time he visited and studied mathematics, botany, chemistry and medicine at ten German universities (academiæ). These were Argentorata, Basel, Ingoldstadt, Altdorff, Erfurt, Wittenberg, Leipsic, Griefswald and Rostock, where he dwelt and studied with Simon Paulli, a distinguished botanist. Thence he went to Stettin, where he spent two years studying astronomy with Laurence of Eichstadt, the most celebrated astronomer of his time. Here Marcgrave seems to have become so proficient that he was of material assistance to his teacher in working out certain astronomical ephemerides, and Manget tells us that the latter gave credit to him in the preface of his work published in 1634.

After traveling in the north of Germany and in Denmark, Marcgrave went to Leyden in Holland, where he spent two years, devoting his nights to the study of astronomy from the tower or observatory of the university and his days to botanizing in the gardens and fields. His masters here were Adolphus Vorstius and Jacob Golius, the former a botanist and the latter an astronomer.

Marcgrave was now in his twenty-eighth year, and in the plenitude of his powers both physical and intellectual. His travel and study of

college. To all who have so kindly helped in making this article cordial thanks are returned.

[3] The authorship of this sketch is an interesting problem, which Mr. Lydenberg has vainly endeavored to solve. He notes that the writer, who makes it clear that he was a personal friend of Marcgrave's and a contemporary of the principals in Count Maurice's expedition to Brasil, could not have been Manget himself, since he was not born until 1652 and Marcgrave died in 1644. With this understanding and to avoid multiplication of words, he will however be hereafter referred to as Manget.

the past eleven years, his residence and work in the various universities, his intimate association with the learned professors he had met, especially the four named above, had tremendously stimulated him. He had received the best that Europe had to give, but he was not content. Manget says that he constantly had before him the saying of his father and grandfather that the world lay open before him.

While in Leyden he received another great and even more powerful stimulus, one which was to determine his whole future life. Amsterdam, twenty-two miles away, was the headquarters of the Dutch West India Company. This company had been formed, not, like its great confrère of the East Indies, for trade and colonization, but primarily to harry the New World trade and settlements of the Spaniards and Portuguese, the ultimate objects being to capture treasure ships and to create a diversion in favor of the Belgians, with whom the Spaniards were at war. In the course of events, however, the Dutch had captured and at that time held the whole of the northeast coast of Brazil.

Marcgrave knew many Dutchmen who had returned from Brazil, and their stories of the new world fired his imagination and tremendously stirred his ambition. He seems to have made up his mind to go to Brazil, not as a mere adventurer, but as a student and scientist. Manget tells us that

> He burned with great desire to study the southern stars, Mercury especially, and he saw the great (unworked) field of natural history and the harvest of no small praise to be gained (from it) in America. Therefore he moved every stone and sought every opportunity for going to America.

Living in Amsterdam at this time was Jan de Laet, "Prefect" or managing director of the Dutch West India Company. Marcgrave knew De Laet and sought his influence and help, and so successfully that he was appointed astronomer to the company was so enrolled on its archives, and was assigned in that capacity for investigation in Brazil.

Accordingly, Marcgrave left Holland, which he was destined never again to see, on January 1, 1638, and after a voyage of two months reached the coast of Brazil. This expedition was under the leadership of Johann Moritz, Count of Nassau-Siegen, to whom was entrusted the supreme command of the Dutch conquests in the New World, and who had preceded Marcgrave into Brazil by a little more than a year. This remarkable man was not merely a great soldier and statesman, but was a lover and cultivator of the sciences in which he was no mean student.[4]

[4] With regard to Count Maurice, the present writer can not do better than quote Swainson's encomium which is attested by all the other writers who speak of the Count, "It is almost inconceivable how this illustrious man, whose life, at this period, would appear to have been spent alternately in the camp and the council, could find leisure even to think of science, still less to have prosecuted it in his closet. Yet the versatility of his mind, and its power of abstraction, was so great that such was actually the fact. He not only patronized and assisted

On this expedition he took with him as his immediate family, Franz Plante, his court preacher (who afterwards became professor of theology at Breda), and William Piso, his body physician, while later there joined him George Marcgrave, astronomer and geographer, and Henry Cralitz, a young German student, who unfortunately died shortly after arriving in Brazil.

Piso was physician to Count Maurice and chief surgeon of the troops. It seems probable that he was also head of the scientific work of the expedition (Driesen, De Crane) since he was a much older and more experienced man than Marcgrave. However, so far as the natural history work was concerned, Piso limited himself closely to that aspect of it which was purely medical, as will be shown later. Marcgrave on the other hand had a much wider field. He certainly practised medicine to some extent, but his larger activities were given to astronomy, geography and natural history, in all three of which branches he did an enormous amount of work, as the sequel will show.

Marcgrave, who seems possibly to have been known to Count Maurice in Holland, before he had been in Brazil many months thoroughly established himself in the favor of his patron. Manget assures us that this was due first of all to the fact that Marcgrave had some knowledge of military architecture. This knowledge was probably made of service to the Count in the building of his new capital, Mauritia, in the environs of Pernambuco.

Be that as it may, Marcgrave certainly rose rapidly in the esteem of his chief, for we find that the latter built for him in 1639 in the city of Mauritia an astronomical observatory of stone from which Marcgrave studied the motions of the stars, their risings and settings, their sizes, distances and other phenomena.[5]

To care for these extensive collections, his generous friend and

the labors of those whom he had engaged for this purpose, but actually worked himself in describing and drawing the various new animals of Brazil, even in the most arduous periods of his government.''

[5] On the island of Antonio Vaez in the harbor of Recife, Count Maurice built after plans by Peter Post a vice-regal palace, Freiburg, in the suburb called Mauritia. This building had two towers which were visible six to seven leagues at sea and which served as beacons to the mariners (Nieuhoff). It was probably one of these which Marcgrave used as an observatory. This was in all probability the first astronomical observatory ever erected in the southern hemisphere and in the new world.

And at the same time he received from Count Maurice a troop of soldiers, which accompanied him throughout those parts of Brazil where he explored, so that he was able to hunt for, capture, collect and dry wild beasts of all kinds, fishes, birds and plants: in all which, collected, preserved and displayed before Count Maurice as if they were alive (*i. e.*, stuffed), he brought great delight to the Count and the highest praise to himself.[6] (Manget.)

[6] This information was given to Manget by Colonellus of Mansfeld, the leader of these troops.

patron (according to Lichtenstein and Driesen) had gardens, cages and fish-ponds constructed in Mauritia. Manget further tells us that Count Maurice called himself the disciple of Marcgrave, and as we shall see later, in his hours of leisure took a considerable part in working up these collections.

In his collecting tours, Marcgrave seems to have pretty thoroughly explored the northeastern part of Brazil, particularly those regions embraced in the present states of Pernambuco, Parahyba and Rio Grande do Norte. How many of these exploratory journeys Marcgrave made is not known, but that he made at least three is certain and for this reason. It seems that from the time of leaving Holland he kept a journal, and that this journal for the years 1638, 1639 and 1640 fell into the hands of the unknown writer in Manget. This man expressly says that the journal for these trips was written up day by day and that he had it in his possession. What became of the journals for the other three and one half years (1641–1644) he did not know.

The first of these journeys was undertaken on June 21, 1639, and lasted for thirty-nine or forty days. The second, begun on October 20, 1640, lasted twenty days. The third and shortest covered the time from December 8 to December 19, 1640. How many other explorations Marcgrave made can not be said, but, even if there were no other extended ones, there was no lack of opportunities for studying natural history, since he had but to go outside the city or camp to find himself surrounded by plants and animals new and hitherto unknown to the scientific world.

It must not be supposed, however, that, because the jungle could be reached in a short distance from the camps, it was easy to see, much less to collect, the animals found therein. All explorers and naturalists in the wilds of Brazil have strongly emphasized the fact that one may travel hours and even days through the forests without ever seeing or even hearing bird or beast. This is, of course, due to the very dense vegetation and to the fact that most of the forest dwellers are likewise tree-top dwellers and are found high up in and *on* the tops of the trees. The wonder is that Marcgrave, in the wild and unsettled condition of the country and with his limited knowledge of the habits of the animals he sought, should have amassed such valuable material. That he let slip no opportunity to add to his collections and to his observations will be shown later, and it is probable that, having become acclimated and having laid the foundation of an acquaintance with the fauna and flora of Brazil, the years 1641–44 witnessed far more scientific activity on his part than the preceding three years.

At last the time came (May, 1644) when, his work having been brought to a stop by the preparations of his chief to return to Holland, he determined to go home also. Concerning this matter the unknown

writer in Manget is very explicit, so much so that it seems well to quote him in full:

> Samuel Kechelius, a distinguished astronomer who has taught for many years at Leyden and who was formerly a messmate of Marcgrave's, has told me of letters sent to him from Marcgrave in Brazil in which the latter announced that he had packed up all his possessions and awaited a favorable wind that by the grace of God he might return to his native land with the renowned Prince (Maurice). But in spite of his determination, and unexpectedly, so Kechelius narrates (and the same others report also), he was sent to Angola in Africa to what purpose he was ignorant, and as soon as he came thither he died.

So died and went to his grave at the age of thirty-four, at the zenith of his activities and reputation, George Marcgrave, who, had he lived but a few years longer to have put into shape his Brazilian collections and observations, would certainly have raised himself to the rank of the first natural historian of his time, and possibly that of greatest since Aristotle.[7]

The scientific fruits of this expedition to Brazil of Count Maurice, of Piso, and especially of Marcgrave, are of four kinds: (1) the astronomical and mathematical MSS. of Marcgrave; (2) the extensive natural history collections; (3) the MSS. of Marcgrave and Piso dealing with the natural history and medicinal matters of Brazil; and (4) the two sets of figures of Brazilian plants and animals, the one in oil and the other in water colors, which will later be referred to.

With reference to the natural history collections which Count Maurice brought back from Brazil, Lichtenstein tells us that in addition to the material amassed by Marcgrave in his explorations, the Count sent expeditions east to Africa and west as far as the Pacific (note Marcgrave's paper on the Chileans, with the figure of the llama, referred to later), and that these brought back many natural history objects. To care for these specimens, the Count converted Freiburg into a museum, and its grounds into a botanical-zoological park. (Van Kampen.)

When at length this illustrious patron of the natural sciences determined to return to Holland, he stripped Freiburg and its grounds of their treasures, and so voluminous were these ("the richest ever brought to Europe in one vessel") that Lichtenstein affirms that Count Maurice supplied his own museum, those of two universities (Leyden being one) and those of many private individuals (Martius notes Seba's

[7] It is a source of no small regret to the present writer that he is unable to give in connection with this sketch a portrait of Marcgrave. In none of the works listed in the bibliography at the end of this article is there such a portrait or reference to any. Mr. Lydenberg has kindly gone through the extensive list of portraits belonging to the New York Public Library, and has also searched several other lists (one containing the portraits of 30,000 Germans) without finding any. It seems probable that there is no portrait of Marcgrave extant.

especially) with such an abundance of natural-history material, that at the end of a one hundred years it had not all been worked up.

That these collections were largely the work of Marcgrave seems more than likely. And indicative of the care which he bestowed on his specimens and of the value set upon them as a result, the following quotation from Manget is in point.

> Samuel Kechelius saw sold at Harlem for 4,000 florins a book of dried Brasilian insects, the names of all of which were written in Marcgrave's own hand.

With reference to Marcgrave's mathematical and astronomical work, we know little about its extent and even less about its content. That he drew plans for camps, cities and fortifications, and made maps of the regions explored, we are told by the writer in Manget.[8] In addition to these there were MSS. of more important character brought back by Count Maurice from Brazil.

De Laet, who was Marcgrave's literary executor, tells us in the preface to Marcgrave's part of the 1648 folio that from notes found among Marcgrave's papers it is clear that our author had worked up his mathematical and astronomical data into a great work in three parts under the title, "Progymnastica Mathematica Americana."

> The first section is on Astronomy and Optics and contains a review of all the southern stars found between the Tropic of Cancer and the Antarctic Pole; many various observations of all the planets and of eclipses of the sun and moon worked out in an original way; new and true theories of the inferior planets, Venus and Mercury, based on special observations; a theory of refractions and parallaxes setting forth the greatest obliquity of the ecliptic; and finally data not only on sun spots but also on other astronomical rarities. The second section is geographical and geodetical, containing a theory of the longitude of the earth and manner of computing the same, demonstrating the true dimensions of the earth from special observations, and disclosing the errors of geographers ancient and modern. The third is based on the two preceding and consist of the astronomical tables of Maurice. [Query, made at his observatory at Mauritia or dedicated to Maurice?]

From certain statements found in the various prefaces and introductions to both the 1648 and 1658 folios, it seems rather probable that Piso had charge of these MSS.; but at any rate it is certain that practically all of the papers in the first and second sections were by order of Count Maurice or De Laet turned over for editing and publication to Golius, the Leyden astronomer and former teacher of Marcgrave. Unfortunately, they seem to have been lost, at any rate, it is certain that they were never published.

[8] Driesen, De Crane and Van Kampen say that Marcgrave worked up four special charts of Brazil, and that Count Maurice after his return to Holland had them etched on copper and had many copies made. These must be the maps which Manget says were common ornaments on the walls of the vestibules in the homes of the better class of Dutchmen. Later a second edition was printed, but as Margrave's name was omitted from this all credit was lost to him.

Thus a great injustice was done Marcgrave, whose work was done over with much *eclat* by Caille and La Condamine. (Lichtenstein.)

In this opinion De Crane also joins, and he intimates further that Huygens also merely rediscovered some of the things which Marcgrave had observed.

De Crane, followed by Van Kampen and Driesen, who undoubtedly copy him, alleges that the reason why Golius never published these MSS. was that they were written in cipher. This, however, seems to be an error, since it is not confirmed by De Laet or by any other writers on Marcgrave's life so far as I can ascertain. The internal evidence bearing on Marcgrave's cipher MSS. will be taken up later. However, with regard to the astronomical tables of the third section, Lalande makes the following interesting statement:

I have also found among the MSS. of M. de l'Isle notice of some observations . . . of several other astronomers, observations which have never been published. Among such are those which Marcgraf made in 1639 and 1640 in the isle de Vaaz in Brazil, which are filed in the archives; but the original remains at Cadiz with the MSS. of M. de Louville and some others which M. Godin had brought there and which are thought to have been in the hands of D. Antonio de Ulloa.

Elsewhere Lalande also notes that Flamsteed had examined Marcgrave's observations on the Ecliptic. These references would seem plainly to indicate that these MSS. were not in cipher.

De Crane alleges that the copy is on deposit in the archives of the French Marine, and Van Kampen thinks that these papers fell into Spanish hands (how he does not say) and that they were made use of by Godin and de Ulloa in their work of measuring a degree of longitude on the plateau of Ecuador in 1835. However, careful search on the part of the present writer has failed to reveal any notice of them in de Ulloa's account of his travels in South America.

One of these MSS. alone has come down to us. Barlæus (1647) seems to have preserved, and Piso in the 1658 folio has published, Marcgrave's "Tractatus Topographicus et Meteorologicus Brasiliæ cum Eclipsi Solaris" (of 1640). While this is based on Marcgrave's own observations, still it is known that to give him more extended data Count Maurice had ordered all the Dutch ship masters in Brazil to make careful notes and even drawings of the eclipse and turn them over to Marcgrave.

It is interesting to note Marcgrave's own statement of his work found in his preface to the Progymnastica as quoted by De Laet (1648 folio).

A work much desired but up to the present time attempted by no one, happily begun by the assistance of the illustrious hero, Johann Moritz, Count of Nassau-Siegen, Prefect of the lands and seas of Brazil, and by God's help after

much labor completed in the new city of Mauritia situated in the Brazilian region of South America, by the author, George Marcgrave, a German of Liebstadt.

Just as the tower of Freiburg, which was given over to Marcgrave's use, was probably the first astronomical observatory ever erected in the southern hemisphere, so it is also probable that Marcgrave's observations of the southern stars were the first ever made in the history of the world. For this reason, even if we do not take into account their scientific value, their loss is irreparable.

Fate, however, has been kinder to us in the matter of Marcgrave's natural-history papers, since these have come down to us fairly complete.[9] However, before taking up their history in any detail it will be necessary to advert to a very unpleasant topic, namely, the relations between Marcgrave and Piso.

The collection of material for the present paper had not gone very far when it was found that Marcgrave had written his "Historiæ Rerum Naturalium Brasiliæ" in cipher. This with other indications led to the conclusion that the relations between himself and Piso were strained. To the unknown writer in Manget, all the principals in this expedition to Brazil were known personally; this he tells us in so many words. Also, he writes:

From many things I gather that Piso and Marcgrave never cultivated a mutual understanding, although Piso called himself Marcgrave's disciple.

Further, this writer seems to have known of many things which he alleges would redound to anything but the credit of Piso. Making due allowance for the partisanship of this biographer, it does seem that Piso living had appropriated to himself much of the credit of Marcgrave dead. Further, it should be borne in mind that Piso went to Brazil as surgeon in chief to the expedition, his scientific work being incidental; while Marcgrave went as a scientist and student, his medical work being incidental. (Piso, Preface, 1648.) While in the 1648 folio, edited by Marcgrave's friend De Laet, Piso gives large credit to Marcgrave, in the 1658 folio, as we shall see later (De Laet having died in 1649 or 1650), he combines Marcgrave's work with his own, giving the latter credit in marginal references only.

In both the 1648 and 1658 folios Piso in the prefaces calls Marcgrave "meus domesticus." Even if we give this the most favorable translation, "of my household," it still indicates that Marcgrave was subordinate to him. Elsewhere there are given a number of instances in which Piso plainly means to convey the idea that he was chief of the

[9] The only one absolutely known to be missing is a paper on the geographical distribution of plants. This is stated on the authority of Driesen. Corroboratory is a statement by De Laet that he had sent to Marcgrave notes transcribed from Ximines, and specimens collected for him (De Laet) from the islands of America that Marcgrave might compare them with the plants of Brazil.

scientific staff and that Marcgrave had his work assigned by him (Piso). While it is probable that the exact facts can never be absolutely ascertained, it would seem that if Piso were scientific chief his headship was merely nominal. So far as the present writer has been able to learn, Piso's only preparation for scientific work consisted in his medical training, and this, it will be recognized, was very limited (he was born in 1596). Marcgrave, however, had had 11 years' study and training at the best German and Dutch universities, and was skilled not merely in medicine, but in botany, natural history, mathematics and astronomy. He was selected by De Laet and Count Maurice on account of these scientific attainments, was given the official post of astronomer with a definite salary, and was the intimate personal friend of Count Maurice, and as such was a member of his official family.

We learn from many sources, but above all from De Laet in his preface to Marcgrave's "Historiæ Rerum Naturalium Brasiliæ," that this was written in the city of Mauritia and in *cipher*. It seems well to quote De Laet (1648 folio).

> When his papers so confused and unfinished were turned over to me by the illustrious Count Johann Moritz, by whose kindness and favor and outlay he had done these things, no small difficulty presented itself at once. For the writer fearing that some one might try to claim for himself his (Marcgrave's) work, should any misfortune by chance befall him before he should be able to make his observations known to the world, had written a good part of those things which were of most moment in certain characters devised by himself as a second alphabet left in secret, which must first be understood and transcribed with a greater effort than any one would wish to assume. Nevertheless, although occupied with other matters, I accomplished this task with great labor.

Speaking on this subject Lichtenstein conjectures:

> From the wonderful activity with which he during his stay in Brazil made and recorded his observations, one may conclude that Marcgrave anticipated an early death and made haste to firmly establish his fame.

And when one reads of his early and almost immediate death, and of the fate of his literary remains, his sound judgment in this matter is to be commended.

However, the present writer, in the light of the data noted above, wishes to call attention to the fact that the astronomical and mathematical papers embraced under the general title "Progymnastica Mathematica Americana" do not seem to have been written in cipher. The bearing of this on the Marcgrave-Piso controversy would seem to be that, since the latter had no mathematical training whatever, there was no danger of his appropriating these papers as his own in case any accident should befall their writer; but that such danger was to be apprehended with reference to the natural-history papers, hence the cipher.[10] So cautious was Marcgrave that some things were written in a second cipher (De Laet, Preface, 1648).

[10] See foot-note to page 256.

However, at last De Laet, who was a man of much learning and ability, completed his task[11] in spite of two additional heavy handicaps. The first was that he was not skilled in natural science, the second that Marcgrave's notes were arranged in no order whatever, those on each animal occupying a separate sheet. The greatest trouble, however, was had with the notes on plants, since Marcgrave had not been able to describe at one time and on one sheet the plant in leaf, in flower and in fruit. These notes, it must be understood, Marcgrave had written in the field and in Mauritia, and it is plain that he intended to edit them to make a homogeneous whole after his return to Holland.

How well De Laet did this work those know who are acquainted with the "Historia Naturalis Brasiliæ" published at Leyden and Amsterdam in 1648 with the following dedication to Count Maurice:

> The Natural History of Brasil, prepared under the supervision and by the kindness of the illustrious Johann Moritz, Count of Nassau, supreme commander of the province and of the high seas; in which not only plants and animals but also the diseases of the country, the character and customs are described and illustrated with more than 500 pictures.

The first section of the volume is composed of Piso's "De Medicina Brasiliensi" comprising four books: I. on Air, Water and Places; II. on Endemic Diseases; III. on Poisons and Their Antidotes; IV. on the Use of Simples (herbs as remedies). This, which is dedicated to William of Auriacum, covers in all 132 folio pages and is illustrated with 104 figures limited to books III. and IV. Of these, three illustrate mandioca and sugar-making, nine are of animals (five snakes, one scolopendra, one sea cucumber, one toad-fish, one frog) and 92 are of plants.

The second section, Marcgrave's "Historiæ Rerum Naturalium Brasiliæ," is dedicated to the Count in the following eloquent terms.

> To Johann Maurice, Count of Nassau, great chief of the lands and seas of Brazil, George Marcgrave of Liebstadt, a German of Saxony, dedicates these things, which during his travels through Brazil, he with indefatigable zeal inquired into, described accurately, and made figures of from life, sought out their names among the natives, and so far as he was able when opportunity offered, investigated their uses, and in this history has arranged them for the use of all students and admirers of natural science, in due acknowledgment and as a sign of gratitude for the greatest kindnesses received from him.[12]

This work comprised 303 folio pages, consisting of eight books and an appendix, and is illustrated by 429 figures. It is divided as follows: Book I., in which are described 149 herbs with 86 figures; Book II. contains descriptions of 48 shrubs and fruit-bearing plants with 39 il-

[11] It should be noted in passing that De Laet adds more than one hundred annotations to Marcgrave's descriptions of plants and animals. These largely consist of data drawn from Ximenes's accounts of the plants and animals of New Spain.

[12] This dedication was written in Mauritia (Manget), and seemingly in anticipation of the untimely result of his journey to Africa.

lustrations; Book III. deals with trees, 104 being described and 75 figured; Book IV. treats of fishes and crustaceans, both fresh-water and marine, 105 of the former being described and 86 figured, the numbers for the latter being 26 and 19, respectively, and in addition one starfish is both described and delineated; Book V. contains descriptions of 115 birds, 54 of these being shown in figures; Book VI. deals with quadrupeds and contains descriptions of 46 and figures of 26, together with 19 reptiles, of which 7 are figured; Book VII. is devoted to insects, 55 being described and 29 figured; Book VIII., the last, has to do with the country, its aborigines and present inhabitants and has 5 illustrations. The Appendix treats of the inhabitants of Chile and contains two figures, one being probably the earliest known drawing of the llama.

> Finally in these eight books are 429 figures for the most part accurately drawn by the author himself. (Statement at foot of table of contents.)

Disregarding Book VIII. and the appendix with their seven figures we find that 301 plants are described and 200 figured. Of animals 367 are described and 222 figured. Of these 668 forms practically all were new to science and the 422 figured had probably never been drawn before.

Despite the fact that Marcgrave knew nothing of the subtleties of classification based on the structure and position of stamens and pistils in flowers, and on the count of fin-rays and lateral line scales in fishes, nevertheless his work in Brazil was an epoch-making one. In bringing to the notice of the scientists of Europe the wonders of Brazil, Marcgrave was the worthy predecessor of the Prince of Neuwied and of Spix and Martius. His history of the natural things of Brazil is probably the most important work on natural history after the revival of learning, and, until the explorations of the Prince of Neuwied were made known, certainly the most important work on Brazil.

But, in giving praise to whom praise is due, Count Maurice should not be overlooked, for it is certain that he alone made it possible for Marcgrave to do all this magnificent work. Van Kampen compares Count Maurice to Napoleon, who on his expedition to Egypt carried a numerous band of savants with him. Piso, however, likens him to Alexander, in which comparison Marcgrave and not himself must take the place of Aristotle. All honor to Count Maurice!

However, it is not the intention of the present writer to go into any extended analysis of the natural-history work of Marcgrave. This has long ago been done and most ably for a large part of the animals by Lichtenstein (1814–15, 1816–17) and for the plants by von Martius (1853–55). It is in the book on fishes that the present writer is most interested, and it does not seem out of place to quote the estimates of some of the great ichthyologists.

Cuvier and Valenciennes (1828) say:

> George Marcgrave . . . the most learned, the most exact, and above all the

one who has most enriched the history of fishes. He made known 100 (105), all at that epoch new to science, and has given descriptions very superior to all the authors who had preceded him.

Gunther (1880) writes:

> Markgrav especially studied the fauna of the country . . . his fourth book treats of fishes. He describes about 100 species, all of which had been previously unknown, in a manner far superior to that of his predecessors. The accompanying figures are not good, but nearly always recognizable, and giving a fair idea of the form of the fish.

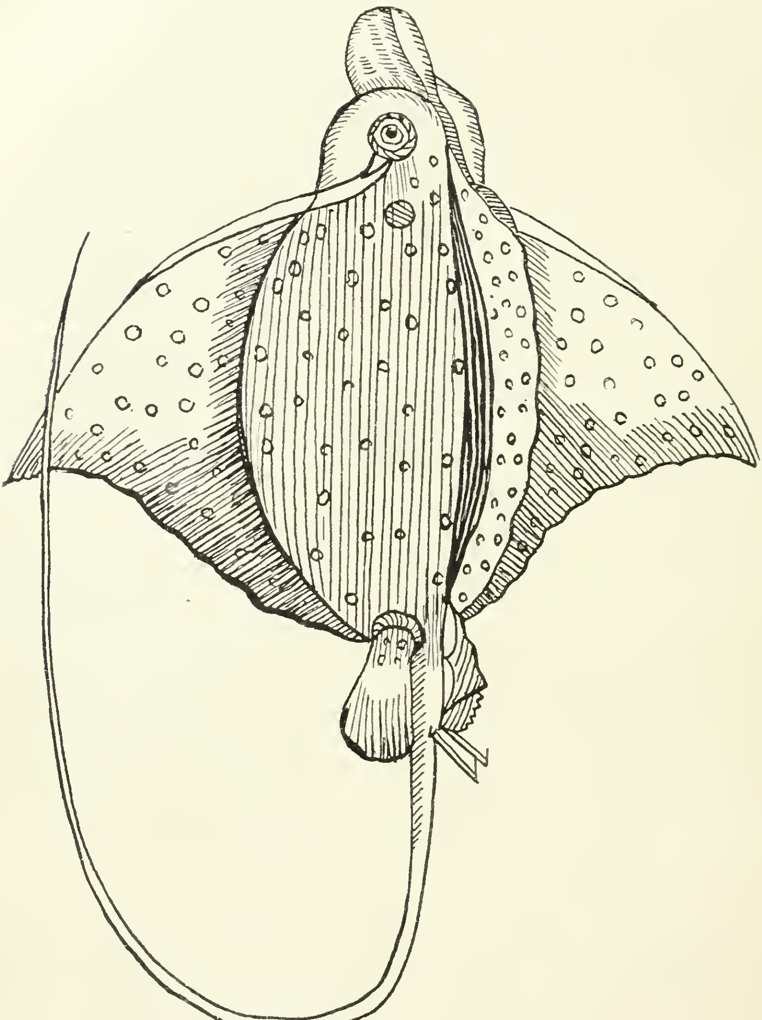

FIG. 1. *Narinari*, AFTER MARCGRAVE, PAGE 176.

Jordan (1905) notes that

> Marcgraf described about 100 species, all new to science, under Portuguese names and with a good deal of spirit and accuracy. . . . This is the first study

of a local fish fauna outside of the Mediterranean region, and reflects great credit on Markgraf and the illustrious Prince, whose assistant he was. . . . There were no other similar attempts of importance for a hundred years. . . .

Since copies of his figures are at hand for illustrating them, the present writer wishes to give here Marcgrave's descriptions of two rather well-known fishes as illustrative of the accuracy of his observations and the care with which he recorded them.

The first, whose figure, number 1, is herewith reproduced from his "Natural History of Brazil,"[12] is the spotted sting ray which we know as *Aetobatus narinari*. Marcgrave's description is as follows:

Of the several species of fish called "Narinari" by the Brazilians, the one which we have described here is *Narinari pinima*. It is called "Raja" by the Portuguese, and "Pylsteerte" or "Siecle" by the Dutch. It is a *Marina pastinaca*.

Its body is large, broad, almost triangular in shape, extending out on both sides into very broad triangular wings, which are fleshy in their make up. Near the tail it has two fins about the size of one's hand rounded in outline and of equal length. Its head, which is thick, compressed and furrowed in the middle, is about as large as that of a good-sized pig.

The mouth rounded underneath is triangular, compressed a little and terminates in a snout. The opening of the mouth is on the ventral surface, 5 inches from the end of the snout. The mouth is 2½ inches wide, toothless, but having in the place of teeth a lower jaw in the shape of a tongue. This is 4 inches long, 1½ inches wide, and reaches to the external opening of the mouth. Likewise there is an upper jaw placed crosswise, 2 inches long and as many wide.

The lower jaw consists of 17 hard white bones having the shape of the letter V and firmly joined to the membranes. Underneath there lie 17 other bones, one under each, of spongy appearance but not so hard. The upper jaw consists of 14 bones, shaped like the letter I and also joined together by membranes. Likewise there lie above these 14 other bones. Moreover, the two jaws are joined to the other bones of the head by membranes (cartilages).

The cavity of the skull, wherein the brain lies, is about 6 inches long and hardly 2 wide. The snout is wholly cartilaginous. The fish has two small eyes about the size of a *nummus misnicus*. Behind these eyes on each side is a large breathing hole capable of holding an apple of ordinary size. Within these holes the leaves of the gills lie hidden. On the lower side at the (hinder) end of the head are five oblong incisions.

The whole upper surface of the body is of a dark (ferreus) color with white spots the size of a *nummus misnicus* scattered over it, while the under part is entirely white. The skin is everywhere smooth and without scales.

The length of the body from the end of the snout to the root of the tail is one and one half feet; the width between the extremities of the triangular wings is 3 feet 10 inches. The length of the fins near the tail is 7 inches, the width 4. The length of the head is 10 inches, the width 7, and it is 1½ feet thick. The tail is 4 feet 3 inches long and its thickness at the beginning is 5 inches, but it gradually becomes thinner. A little behind the beginning of the tail, there is a small short fin a little more than an inch long; and just behind this standing

[12] The Library of Congress possesses two copies of this rare work. One has the wood cuts plain, the other colored by hand. The writer's own copy has plain figures.

erect are two little hooks curved like fish hooks and 3 inches long. Its flesh has a good flavor and is sufficient to feed 40 men.

He thus describes the toad-fish:

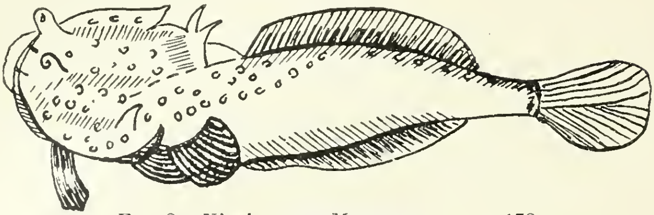

FIG. 2. *Niqui*, AFTER MARCGRAVE, PAGE 178.

This fish is called Niqui by the Brasilians and by our people Pieterman.[13] It has a thick head, a large frog-like mouth, is toothless, has a thick tongue, and the lower jaw is a little longer than the upper. The anterior middle region of the body is rather broad, the hinder narrow and rounded. It is at most 6 or 7 inches long and in the anterior part the breadth is about 1½ inches, or a little more. Its eyes are small and prominent, set on cylinders like those of the land crab, the pupil is dark and the iris an ashy-brown. It has large gills and a little back of these a fin (on each side) an inch long and wide, rounded at the edge, on the belly beneath these a little further back the gills join. The fin on the mid-dorsal region is continued almost to the tail, an inch and one half high it grows narrower behind, and on the hindmost parts of the underside of the body there is a corresponding one. The tail is more than an inch long, of less width, shaped like a parallelogram, and rounded at the extremity. In front of the beginning of the dorsal fin it has two strong spines, and above either post-branchial a sharp one. It is covered with skin whose color varying from dark to black, is gray mixed, plainly seen over the whole back, head and sides, and on all the fins. The belly is white, and on the sides it is rather white than black or gray. Over the whole back, head and sides there are scattered little black spots the size of a poppy seed. It lies hidden in the sand near the seashore, and wounds the feet of men stepping on it.

The great excellence of Marcgrave's book, and that which distinguishes it from the works of Gesner and Aldrovandi, is that it is absolutely original. These naturalists, while they did great and good work for natural history, were compilers, copiers, men who systematized the observations of travelers, but who themselves never saw a tithe of the animals whose figures and descriptions they put into their great folios. Hence it is not strange that their pages are filled with figures of mythological monsters, which make it hard at times for the modern naturalist to give them the credit they deserve.

Not so Marcgrave, however. He went to Brazil and lived in its wilds. His figures and descriptions were made from the animals themselves, and very probably in most cases from life.[14] Furthermore all or

[13] The modern name of this toad-fish is not known to the present writer. Jordan and Evermann ("Fishes of North America," Vol. III., p. 2315) refer to "The Brazilian genus *Marcgravia* (*cryptocentra*) . . . ," which is possibly the fish above described.

[14] At Freiburg in Mauritia, Count Maurice had gardens in which large numbers of the plants of the country were set out, he also had cages in which

almost all of the plants and animals in his natural history of Brazil were new to science, yet his figures and descriptions are so accurate that the student of to-day can recognize them at a glance. The following incident will show the care with which he made his observations. In his descriptions of the spotted sting ray quoted above, he gave the number of teeth as 14 for the upper jaw and 17 for the lower. By an interesting coincidence the numbers were the same in the first specimen of this ray ever taken by the present writer.

That Piso took much part in editing the "Natural History of Brazil" (1648) seems from various indications very doubtful, and indeed Lichtenstein declares that in Piso's absence De Laet attended to the editing of the whole work. Whether he had any part in it or not, Piso became very dissatisfied and accused De Laet of doing his work hurriedly and superficially. Ten years later (1658) he published a great folio under the title "De Indiæ Utriusque Re Naturale et Medica" in the endeavor to improve on the previous work. The first part of this folio, which he dedicated to the Elector of Brandenburg, bears title as follows: "Historiæ Naturalis et Medicæ Indiæ Occidentalis" and consists of Marcgrave's Natural History of Brazil and Piso's Medicinal Plants of Brazil interwoven to form five books: I. on Climate; II. on Diseases; III. on Animals; IV. on Plants, and V. on Poisons and Antidotes. It covers 327 pages. Next comes Marcgrave's "Tractatus Topographicus," etc., as previously noted, 39 pages in length. Next he incorporates Jacob Bont's "Historiæ Naturales et Medicæ Indiæ Orientalis," 160 pages, and concludes with his own "Mantissa Aromatica," 66 pages.

Not only is this not an improvement on the preceding work, but in many respects it is distinctly inferior. Marcgrave's work on the plants of Brazil suffers abbreviation and loses its identity in becoming interwoven with Piso's data from the medical side. The animal section, however, suffers most for Piso was even less a zoologist than a botanist. It seems that he no longer had access to the original drawings (to be described presently) from which the illustrations were prepared for the first edition, so his figures were copied from the 1648 edition, or made up from the descriptions, or wrongly placed in the text, or omitted altogether (Lichtenstein). On the whole this edition adds little or nothing to Piso's reputation.

It is now necessary to speak of the fourth division of the scientific memorabilia of the expedition of Count Maurice to Brazil. In 1786, Schneider made known to the world the presence of these priceless treasures in the following words.

I have so often heard of a collection of original paintings of Brazilian animals, which Prince Johann Moritz of Nassau, formerly governor of the one

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the animals were kept, and fish ponds full both of salt and fresh water fishes. (Nieuhoff.)

time Dutch Brazils, had made and had annotated in his own handwriting and finally after his return had given to the great Elector of Brandenburg, that I was desirous once for all to see these *Handschriften*. Finally in the early part of this year, my wish was realized. I found this collection in the Royal Library at Berlin in 2 folio *bänden* of different sizes collected under the title "Icones Rerum Brasiliensium." All the sheets are designated by numbers, however without a perfect arrangement having been brought about in the two different *bänden* separated the one from the other. . . . By comparing them with (the figures in) Marcgrave's Natural History of Brazil, it is plainly shown that Marcgrave had all the best painted figures copied as wood cuts in the same size. How faithfully? Thereon we have his own word. The added remarks are in Dutch and we know certainly by the Prince's own hand,[15] and everywhere agree with Marcgrave's text. However, they are extremely brief and indicate only the sizes and relationships of the animals with one another. The collection itself may no longer be complete, at any rate I have in vain sought therein for some of Marcgrave's sketches, however there are to be sure some sketches which Marcgrave did not copy, and some few animals which he did not know. In the main I note that on careful comparison this collection explains Marcgrave's text in general. This also can not be in error, since Marcgrave has only been able to afford woodcuts, and his draughtsman has not seldom copied the original figure entirely wrong; in the annotated collection on the contrary all the animals have their natural colors whose differentiation so often must give the essential points of distinction between nearly related species and genera.[16]

Next Schneider goes on to express the wish that more authors like Bloch might illustrate their books from this magnificent set of paintings. Bloch not only was acquainted with these drawings but copied a large number of them in his "Ausländische Fische" and in his grand "Ichthyologie." In the preface to volume 6 of this latter work (1788). Bloch describes this collection of drawings as made on white parchment and consisting of two sets.

The first contains 32 quadrupeds, 87 birds, 9 amphibians, 80 fishes, 31 insects, some shells and star fishes and one cuttlefish; in all 183 sheets. On each is a figure of a fish, bird, quadruped, amphibian, insect or worm. All are very beautifully designed and painted in part with very bright and beautiful colors. Above the animal one finds the name which it bears in Brazil, and below mention is often made in the Dutch language of its size.[17] The second part also on white parchment . . . contains two quadrupeds, 15 birds, 46 amphibians, 45 fishes, 46 insects and several pages of plants . . . it consists of 114 sheets on which one finds the designs mentioned which have been made by the same hand as those in the first part.

That Bloch's reproduction of these paintings went far to make them known to the world is not to be denied, indeed, the present writer first

[15] Lichtenstein comments on the characteristic half jocular notes added by Count Maurice, of which the following may be quoted. On the sheet containing the figure of the ant-eater, *Tamandua guacu*, the Count has written: "This is the great ant-eater, as large as an otter. He sticks his tongue into a hole, the ants sit down on it, and then he draws it into his mouth. The tongue is about one half an ell long. . . . He can not run at all."

[16] For this transcript I am indebted to the courtesy of Dr. Perlbach, of the Royal Library of Berlin.

[17] See Fig. 3.

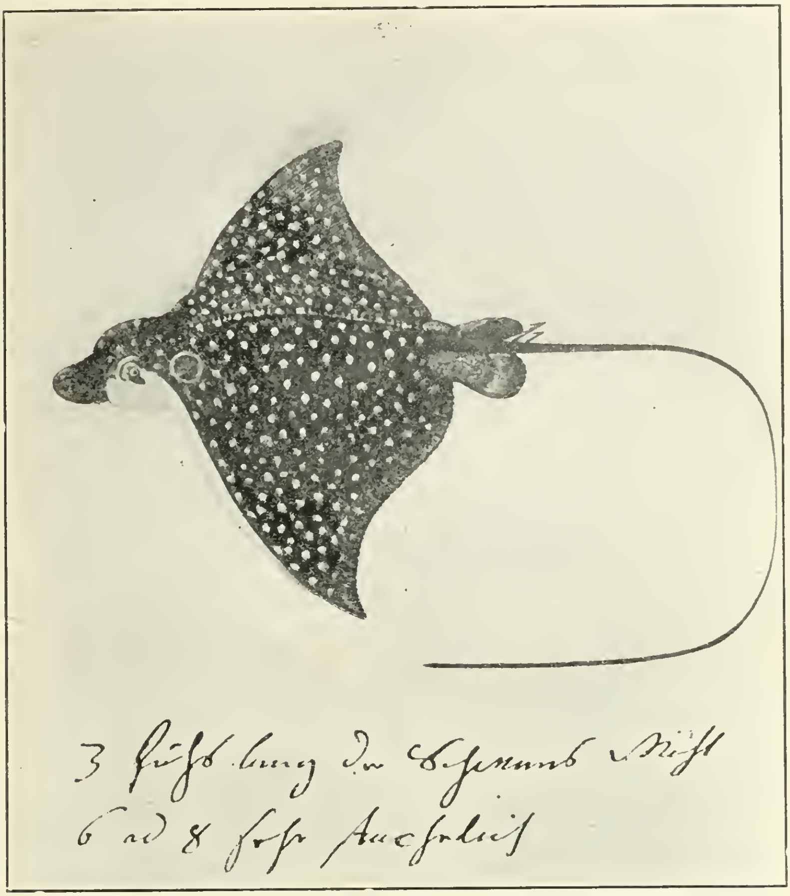

Fig. 3. Photograph of the Water-color Painting of *Narinari.*

came to know of them through the preface to Volume VI. of the "Ichthyologie," but as to the fidelity of the reproduction let Cuvier and Valenciennes speak.

Bloch had copied many of these figures in his Ichthyologie, but without seeming to doubt that they were designed by the Prince, and what is more reprehensible in him, in adding or taking away or changing a great many things very arbitrarily.[18]

The set of drawings above referred to are in water colors and are thus labeled in the Royal Library of Berlin: "Brazilianische Naturgegenstände (Collectio rerum naturalium Brasiliæ) in two Bänden. Libri picturati A. 36. 37."

Their authorship and history will be discussed later. Figure three is a photograph of the painting in this collection of the spotted sting-ray, Narinari. When there is taken into account the fact that this

[18] This was probably written by Valenciennes, who made a special trip to Berlin in 1826 to inspect these paintings.

water-color drawing is about 270 years old, one marvels at its freshness and clear-cut outlines. That it is wonderfully accurate, the present writer, who has devoted considerable study to this fish, can attest.

Along with the preceding lot of drawings in the Royal Library of Berlin is a large number of oil paintings bearing the following title: "Theatrum rerum Naturalium Brasiliæ. (Icones) in 4 Bänden. Libri picturati A. 32–35." The first reference to these in the literature is in an anonymous article, in *Neue Zeitungen von Gelehrten Sachen*, Erster Theil, No. 4, 1717, bearing the title ". . . Ausser diesen Ost-Indianischen Wercke ist in der Konigl-Bibliotheck auch ein West-Indianisches unter folgenden Titel enthalten, Theatrum rerum naturalium Brasiliæ, imagines, etc." This author notes that these oil paintings are in four *bänden* and that in the first are 357 fishes, in the second 303 birds, in the third 245 "other animals from men to insects," and in the fourth 555 plants, 1,460 in all. He refers to a smaller collection in water-colors but does not give the number of drawings in it.

In 1785, Boehmer in his "Bibliotheca Historiæ Naturalis," etc., gives a brief abstract of the preceding notice. The next reference is even still more obscure. Lichtenstein tells us that in 1811 Illiger brought these to the attention of the modern scientific world. Just what he did can not be said for in spite of every effort it has been impossible to run down this reference. From this fact we may perhaps judge it of little importance. Last of all Lichtenstein (1814–15) found them and has described them at length. His paper will be referred to later.

There can be no doubt that all these figures were made in Brazil and that Count Maurice brought them back with him in 1644. On his return this illustrious man was received in a manner befitting his distinguished services to the Dutch people and honor after honor was heaped upon him. In 1652 he entered the service of the great Elector of Brandenburg, by whom he was raised to the rank of prince. Between these two illustrious men a strong friendship arose, which was not broken until the death of the prince in 1679 at the age of 76, at which time he was governor of Berlin.

The two sets of drawings of Brazilian objects, from the smaller of which in the meantime the figures for the Natural History of Brazil had been made, were bequeathed by him to the knowledge-fostering Elector. By the latter they were placed in the hands of Dr. Christus Mentzel, the court physician and great favorite of the Elector, who was a skilled linguist, that they might be arranged in order, bound in volumes and preserved in the library of his capital, Berlin.

The oil paintings, which were on separate sheets, were collected by Dr. Mentzel into 4 volumes now labelled "Libri Picturati A. 32–33–34–35," and the sheets were arranged in logical order and accompanied by the Brazilian names and the references to Marcgrave and

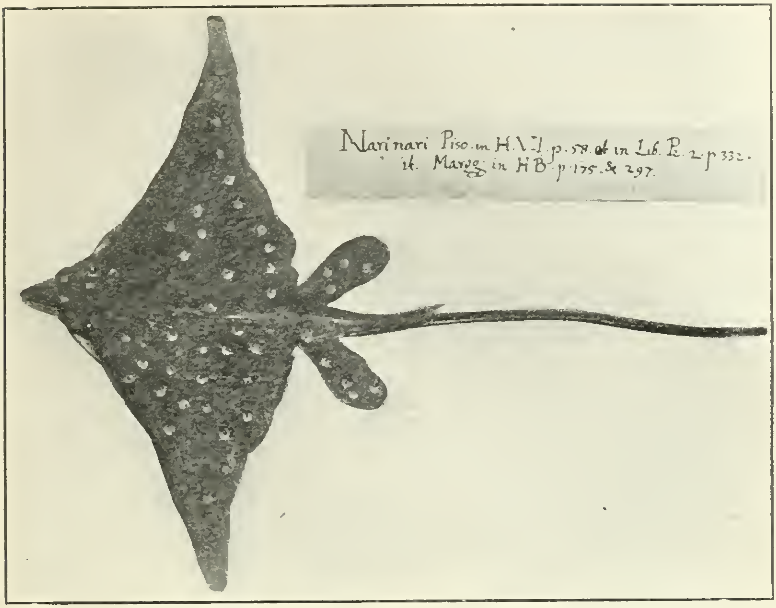

Fig. 4. Photograph of the Oil Painting of *Narinari*.

Piso where a fuller description can be found, also there are references to the water-color collection.[19]

For this collection Dr. Mentzel had an illuminated title page painted, which is reproduced herein as Fig. 5. It seems that considerable time was expended in working out a classification of this collection, for the title page is dated 1660, the preface 1664. Through the courtesy of Dr. Perlbach, of the Royal Library of Berlin, this photograph of the title page and a copy of Mentzel's preface have been received. The latter unfortunately gives no additional data. However,

> Science owes him thanks that he, in this fashion when they had almost perished, preserved the chief memorials of this expedition to Brazil. (Lichtenstein.)

In this manner was preserved to posterity this invaluable collection of paintings. However they remained practically unknown for 150 years until Lichtenstein in 1814–17 in the *Abhandlungen* of the Berlin Academy made known their great worth. His first paper is preceded by an historical account and a critical discussion of the work of Marcgrave and Piso in Brazil which have been a source of inspiration and have supplied much data to the present writer. Then he follows with a critical discussion of both text and figures in the "Natural History of Brazil."

The water-color drawings are also preserved in the Royal Library of Berlin, but it is not clear just how they came thither. However in working out the data found in Driesen, the following interesting facts

[19] See Fig. 4, the spotted sting-ray, *Narinari*, previously described.

FIG. 5. PHOTOGRAPH OF DR. MENTZEL'S ILLUMINATED FRONTISPIECE TO THE COLLECTION OF OIL PAINTINGS.

came to light. In 1652 Count Maurice transferred to the Elector of Brandenburg for the sum of 50,000 thalers a great collection of Brazilian curiosities. No money, however, seems to have changed hands, but the Elector transferred to the Count as security an extensive piece of

property in the city of Cleve. The bill of sale or catalogue of the collection is dated February 18, 1652, and in it as given by Driesen number 14 reads

> A great book in royal folio, and another somewhat smaller, containing (figures of) men, four-footed animals, birds, reptiles, fishes, trees, herbs and flowers, wherein everything, which was seen and found in Brazil, is figured in miniature cleverly after life, with names, qualities and peculiarities attached (in labels). Number 15 contains more than 100 Indian paintings done in oil on paper and not thus bound up.

Driesen notes that of the two *bänden* noted under number 14, the first contains 455, the second 488 sheets commonly with but one drawing, while the inventory says in one place 100, and in another "several hundred." However, since the total number of drawings in the collection to-day aggregates 1,460, Driesen thinks (p. 109) that only a small number were acquired by purchase, the great bulk coming to the Elector as a gift from Prince Maurice.

There now presents itself the interesting question as to who made these paintings. We learn from Manget that Marcgrave was a skillful painter. Marcgrave in his dedication of the "Historiæ Rerum Naturalium Brasiliæ" to Prince Moritz says that he (Marcgrave) made from life the figures contained in it. De Laet in his summary of Marcgrave's eight books says that the figures were drawn by the author. Comparison of the figures in Marcgrave's book with the two sets of drawings shows conclusively that these were made from the water-color paintings. Hence it is a sound conclusion that Marcgrave made the water-colors.

However since these water-color drawings bear notes in Prince Maurice's own handwriting (Mentzel and others expressly say that the Prince made them), Schneider, Bloch and Swainson think that he painted them. Lichtenstein, on the other hand, makes the following pertinent suggestion:

> . . . there is ground perhaps to find this meaning therein, that the Prince himself, who loved Marcgrave very much, has added to this and not to the larger (set) remarks in his own handwriting.

Furthermore to the present writer there seems to be strong grounds for thinking that Prince Maurice made some of these drawings himself. Lichtenstein tells us that the prince "with his learned assistants studied, described and figured the plants and animals of the country."

Comparison of the handwriting on the bottom of the water-color drawing of the spotted ray (Fig. 3), with the facsimile of a letter of Count Maurice's inserted in Driesen's text, leads to the belief that they were written by the same hand.

Lichtenstein, who has gone deeper than any one else into the question of the authorship of these figures, has satisfied himself that Marcgrave made the majority of the water-colors. Here follow the five points on which he bases his belief: (1) Marcgrave says that he drew

them and Barlæus confirms this; (2) the characters in which the names are written are German rather than Hollandish; (3) in likeness and color they accord closely with Marcgrave's descriptions; (4) the wood cuts in Marcgrave's text were for the most part made from them; (5) no other than Marcgrave could have made them. However he further conjectures that since they are smaller and he thinks "of less skillful perfection" that they are copies of the oil paintings. The two figures of the spotted sting ray previously given are the only ones which the present writer has seen. but to him there is no doubt that the water-color drawing was made from life if either is a copy it is the oil painting, which, however, looks as if it had been made from a dead and dried specimen. In the mind of the present writer there is no doubt whatever that Marcgrave himself made all or almost all of these water-color paintings.

Not so easily determined is the authorship of the oil paintings, concerning which Lichtenstein conjectures that they were made by certain "nameless artists" who went with Count Maurice to Brazil. Cuvier and Valenciennes and Driesen content themselves with saying that they were painted by the order of the Count. Piso in the introduction to the 1658 folio says:

> . . . I have added figures drawn from life by the painter who wandered with me through those wilds.

Hence it seems pretty well established that Count Johann had with him another painter besides Marcgrave.

However, Driesen (1849) very effectually clears up this mystery. He says that

> Herr Waagen, Director of the Galleries of Paintings of the Museum of Berlin, has ascertained the painter to be Franz Post of Harlem, brother of the celebrated architect Peter Post. Dutch authors expressly report that Johann Moritz highly prized certain Brazilian landscapes painted on canvas by Franz Post and brought back by him from Brazil.

Now Peter Post was in Brazil with Count Moritz and was the architect of the palace called Freiburg and of the surrounding gardens on the island of Antonio Vaez (Nieuhoff). That his brother accompanied him seems very probable.

Martius (1853–55) arrives at essentially the same conclusion, having probably obtained his data from Driesen. He expressly states that this artist came back from Brazil with the count. Further internal corroboratory evidence is to be found in this statement from De Laet in his "L'Histoire de Noveau Monde ou Description des Indies Occidentales" (1640):

> I have received from a certain young man of our country, rather expert in the art of painting, three figures of other fishes which are taken everywhere in that sea (Maranham on the northeast coast of Brazil).

These figures are so nearly identical with the like in Marcgrave's

book that they must have been printed from the same blocks, or that both sets of blocks must have been made from the same paintings. It is of course possible that this "certain young man" was Marcgrave himself.

These then are the scientific fruits of the life of George Marcgrave. Of his "Progymnastica Mathematica Americana" but a fragment remains. His splendid "Historiæ Rerum Naturalium Brasiliæ" was edited by an alien hand. His magnificent natural history drawings, the like of which the world had never seen before, were lost to the world for 150 years. His splendid collections were scattered to the four winds. His fate is surely a melancholy one. Cut off at the age of 34 at the very zenith of his powers, what a loss to the world. Recall the results of his six and one half years in Brazil. What would it have meant to science to have had him edit his own MSS., publish his own drawings, describe his own collections; in short, to have published his projected great "Natural History of Brazil," which was intended to embrace the inhabitants of the air, the land and the water, and of which but these splendid fragments remain, a mighty memorial to his genius. Well may Lichtenstein call them a "precious legacy," and ask if another country has ever had in its first exploration such a full and exhaustive account of its natural history. To quote further from Lichtenstein:

> These . . . are . . . only a small part of what he would have accomplished in a longer life, and are an example of the pitiable fate which brought to an early end such an able student of science. How many errors, how many empty surmises, how many useless debates, we would have been spared if Marcgrave himself had been able to arrange and communicate his observations.

Had he lived, the present writer believes that our knowledge of the natural things of Brazil would have been more advanced in the year 1650 than it was in the year 1800.

After escaping the dangers of the deep, the accidents and epidemics of the camp and the siege (on two occasions of which he barely escaped with his life), after coming safely through the perils of forest and flood, of fever and wild beasts and poisonous snakes and cannibal savages, this able man came to his death of endemic fever in that pest hole of all the ages, the Gold Coast of west Africa. To die, at 34 years, at the zenith of his power, to leave unfinished his great work, what a loss to the world! Well may Lichtenstin call him one of the great heroes of science.

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THE REAL PROBLEM OF COMMISSION GOVERNMENT

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THAT no problem has laid a severer tax on the political genius of our people than the perplexing problem of city government every student of our political experience knows. Ever since James Bryce called attention to "the one conspicuous failure of the American people"—the failure of the city governments—our publicists and statesmen have been searching restlessly for the model system of government which was to rescue the cities from inefficiency and misrule. Incidentally, a certain class of politicians has exerted itself with equal vigor to render ineffectual the efforts of these workers for a new municipal era.

To say that the new forms of government which constitute the fruits of this reform quest have been complete successes in practical operation would be as far from the truth as to say that they have been complete failures. Practically all of the new forms of city government launched during the past thirty years wrought some sort of improvement in municipal conditions; but, with one exception, it can not be said that any one of them proved so efficient as to give promise of becoming the prevailing municipal system in the United States. Each new plan was set in motion amid brilliant prophecies for the future city government; but in due time the charm which had brought the initial success wore off and the prophecies went unfulfilled. The tale was "full of sound and fury, signifying nothing."

A striking exception to the usual reform tradition is apparently revealed in the story of the commission plan of city government. About ten years ago a great tidal wave swept a substantial part of the city of Galveston, Texas, into the Gulf of Mexico, and the necessity arose for supplanting the notoriously inefficient aldermanic government of that city with a government which should be equal to the task of restoration. A plan was devised by which all municipal powers were intrusted to a single body of five men, each one of whom was given supervision of one of the city's departments, for the proper management of which he was held responsible. The new system, which came to be called the "commission plan," proved unusually efficient and was adopted by several other Texas cities. To-day more than a hundred cities located in all parts of the country are being admirably governed

under this system, which is in a fair way to becoming the prevailing form of municipal government in the United States.

The story of the commission government was recently made the subject of an address in the senate of the United States by a member who was convinced that the new system was such an important discovery in popular government as to warrant calling the attention of the whole nation to it. Well may it be said of this, as of the other new municipal systems, that its early story has been "full of sound and fury." Is it also to be a tale "signifying nothing"? Is the dream of a new municipal era which has been aroused by the wonderful success of this new instrument of democracy destined to vanish as the former dreams have vanished?

Any significant answer must come from an inquiry into the efficiency of the new system—an effort to find out whether the principles underlying the new government are sound in the light of our municipal experience. Of course, many people believe that municipal efficiency is not to be found in any *form* of government, that it is the type of men in charge of the government and not the form of government that determines the character of the administration. Excellent administration, these people say, has been obtained under a poor system, and poor administration under an excellent system; therefore

> For forms of government let fools contest
> What's best administered is best.

The protest is itself an admission. If the form is unimportant, why such violent opposition to a change in the form? As a matter of fact, although the character of the public officials is an essential factor in the success or failure of a municipal administration, the type of political organization under which the officials work is also important. That inefficient officials will fail to give good government, no matter how excellent the system under which they work, is plainly borne out by American experience; and it is equally apparent that efficient public servants will not be able to secure the maximum of efficiency, and, indeed, will be very apt to obtain a minimum of efficiency, if handicapped by a system of government which is ill-adapted to the work to be performed. Moreover, the system exerts an important influence in determining the character of the men who are attracted to the public service. If it is so organized as to discourage the candidature of able men, an inferior type of elective official will result, and the subordinate administrative service will suffer accordingly. The inquiry into the efficiency of the commission plan, then, may be resolved into two questions: (1) Will the new system serve to attract efficient men into the elective offices? (2) Is the new system conducive to the application of approved methods to the public administration? In other words,

is it so constructed as to provide for the performance of the actual administrative work by men of technical training and experience?

That a higher grade of municipal official has been secured under commission government is obvious from the higher standard of public service which, even opponents of the new government concede, has obtained under the new plan. It would be difficult to assign any one cause for this. No doubt the method of electing the commissioners at large, instead of by wards, has been largely responsible; for the municipal election is thereby made less susceptible to control by the ward boss. Thus, under election at large, the political leader who is known and recognized by the general electorate has an immeasurable advantage in the election over the ward leader who is without support outside the confines of his own ward—an advantage which tends to eliminate the latter type from the contest. Log-rolling is commonly regarded as the pernicious accompaniment of the ward plan of election, but log-rolling in itself is a lesser evil than the ward type of municipal candidate: the domination of the election by the ward politicians has frequently shut out the higher type of political leader from municipal politics.

However important a factor the general ticket plan of election has been in bringing a better grade of men into the city's service, the conspicuous character of the commissioner's office has probably been more important; for, if the elective officer under the commission plan had been wrapped in the same obscurity which gathered around that provided by the ordinary American city charter, it is extremely doubtful whether the character of the public official would have been perceptibly changed. On this point the experience of American cities speaks decisively. Nothing has been more influential in keeping competent men from the public service than the curtailment of the powers of municipal officers which took place during the latter half of the last century. In some instances these powers were juggled by the state legislature in the interests of the dominant party in the state; in others they were distributed among a number of newly created officials no one of whom was conspicuous for his power to accomplish results in the public service—a change which was likewise dictated by party interests. The result was the same in either case: whether the powers were usurped by the state legislature or divided among numerous municipal officials, the individual office became less important and the type of incumbent less efficient. Thus, the experience of these years proves that the character of a public office rises or declines according as the powers associated with it are increased or curtailed. It is this fact which furnishes the key to the success of the commission plan of city government.

In the commission government the public official has not been made conspicuous so much because of any cession of power to the municipality by the legislature as because of the concentration in a small govern-

ing body of the powers already possessed by the municipality, and hitherto exercised by a large number of officials. The distinction which attaches to the commissioner's office, together with the consciousness that due credit for individual achievement will not be divided among a number of officials, gives to the position an attractiveness which is all the more effective because allegiance to the ward machine is not necessary to obtain it. "I should never have presented myself as a candidate for city office under the old government with its divided powers and doubtful honors," declared one of the commissioners of a New England city to the writer. Such men are not anxious to hold office where positive achievement is so difficult and credit for whatever is accomplished goes to nobody in particular.

It must not be inferred from what has been said that the popular political leader has been eliminated from municipal government under the commission plan. This mistaken inference has been the ground for much faulty reasoning about the new system, and has probably done more than anything else to obscure the real issue in the movement for commission government. Thus honest political leaders and their followers are frequently prejudiced against the new system because of their belief that its object is to banish the popular leader from municipal politics and to substitute for him the so-called "high brow," or "silk stocking," type. Government by real representatives of the people is to be superseded by government by the "intellectual" members of the community. The same opinion is reflected in comments upon those commission government elections in which a popular political leader or ex-official has been successful; the result in nine cases out of ten is regarded as a "reaction," a sign of the decay of a hitherto promising new system.

It can not be too emphatically stated that the assumption of those who believe that commission government means the elimination of the popular political leader is as mistaken as their fears are groundless. Everywhere the elections in commission-governed cities bear testimony to the fact that the political leader will be elected under a system of universal suffrage regardless of the form of government. The most widely known and most successful of the new governments have been in charge of men of this type. Thus the people of Des Moines, in the first election held under the new charter, rejected the slate of the reform element which had been back of the charter movement, and placed the new government in charge of popular leaders who had been opposed to the new system. The people of Houston in the last election, placed on the commission two popular politicians. A majority of the members of the Haverhill commission are political leaders who have served under the old government in that city. These cases are suffi-

ciently typical. Commission government has drawn its elective officials from the class of sympathetic political leadership as well as from the "reform" or "intellectual" elements of the community. It would perhaps be accurate to say that the new system has generally meant a higher grade of *politicians* in the public service. "All this goes to show," writes a Houston citizen, "that such a thing as lifting municipal government from the level of politics is an iridescent dream." Perhaps it is best that this should be so; if commission government can make the popular leader a careful, responsible supervisor of the city's business, it will do what the aldermanic system has never succeeded in doing.

The logical result of the persistence of this political habit of the people to elect the popular political leader to public office has been usually the intrusting of the commission governments to men of sound but ordinary ability. Here again we encounter the mistaken impression which has had wide currency among those interested in the new form of government, that the commission governments have been run by men of extraordinary personal powers, by experts in administration. A review of the personnel of the new governments does not reveal the grounds for this assumption. Even the commissions which have had the greatest success in administration—for example, Galveston, Houston, Des Moines, Cedar Rapids and Haverhill—have not been made up of men of unusual attainments.

An appreciation of the deep-rooted tendency of our voters to place their cities in charge of men of ordinary ability has led some practical students of the question to assert that the commission plan is foreordained to failure because it provides for the popular election of the city's administrative department heads. "The rock upon which American cities have split is the popular election of administrative officials," a critic observes. The objection touches on the vital problem of the commission government—what the exact function of the elected commissioner should be. But, in the present stage of the development of commission government, it is not possible accurately to designate the commissioner's function as uniformly supervisory or administrative. In some cities he is in effect an active superintendent devoting his entire time to the details of his department; in the majority of cases, however, he acts in a supervisory rather than administrative capacity, and the actual work of the department is carried on by subordinate officials of technical training and experience. The varying charter provisions, some requiring the commissioner to devote all of his time to the work of his office, and others permitting him to devote but a part of his time, show plainly that the real nature of the commissioner's function is not yet clear even in the minds of the proponents of the new system.

Still it is eminently important to the success of the new system that the nature of the commissioner's function as head of one of the city's administrative divisions should be clearly defined and understood. This necessity results from the experience of American cities with the problem of administration. The method, prevalent in every American state, of selecting municipal administrative and technical officials by popular vote, has been a stumbling block in the path of our unfortunate cities. The most vicious legacy which Jacksonian Democracy bequeathed to American politics, profoundly influencing the political ideas and methods of our people during the first half of the last century, was the belief that the selection of administrative officials by appointment and for a permanent tenure meant the growth of a class of office-holding bureaucrats, and that the democratic doctrine of equal opportunity demanded that all should have a turn or a chance of public office. This then novel application of the democratic principle, exemplified in the federal service by the spoils system, led, in the state and local governments, to the popular election for short terms of purely administrative officials. It is a curious fact that the state governments, which imitated the federal system in most respects, have always departed from it in one of its most important features—the centralization of the administrative service in the hands of the chief executive.

In application this principle did not lead to the expected results. Experience proved that to exercise intelligence and discrimination in the selection of numerous officials was beyond the power of the voters; especially was a wise selection of expert administrative officials impracticable in view of the natural inability of the ordinary voter to judge of the technical qualifications of the different candidates for the place. The logical result followed: the voter, in his confusion and helplessness, came to depend upon the party organization, which now assumed the selective function supposed to be exercised by the voters—an excellent illustration of the soundness of the political maxim that a system of government which gives to the voters a power which they are not able to exercise takes from them that power. Popular selection meant party selection in such a case, and party selection was based upon considerations of *availability,* not of *efficiency.* The best candidate for the office requiring technical skill and training was, from the point of view of the politicians, not the man whose experience fitted him for the place, but the party worker whose usefulness to the "Organization" might be conveniently recognized and retained by giving him the office. Essentially, the failure of the Jacksonian political builders in thus modifying the earlier political system was a failure to distinguish between political functions and functions of a purely administrative or technical nature: in its willingness to sacrifice efficiency to democracy,

the method secured neither; effective popular control of public officials became as impracticable as administrative efficiency.

The municipal needs of the present day are stronger than ever in their demand for a system which will insure administration by experts. The increasing social and economic complexity of modern urban life has entailed burdens and obligations hitherto unknown to local government, and if the work of meeting these needs is not carried on with the assistance of permanent experts the cities must fail in their obligations. At the same time it is plain that government by experts alone is undesirable and out of harmony with American political ideas. A staff of permanent officials which is out of touch with the electorate tends to develop into a professional bureaucracy, tied up with red tape and unresponsive to the popular will and needs. It is therefore necessary that the expert should be under the constant supervision of the layman, who will thus form a connecting link between the professional staff and the people. In this way the permanent official will be brought into contact with the needs of the people, and the people, through their elected supervisors, will possess the means of controlling the permanent official. As President Lowell, of Harvard, put it at a recent meeting of the National Municipal League.

> The current management and, for the most part, the suggestion of improvements ought to lie with the expert, but he ought to work under the constant supervision and control of unprofessional men representing the community at large. The expert ought to devote his whole time to the business and receive a salary high enough to pay for the whole time of a man with the capacity required. The person who oversees him ought to be expected to give far less of his time. If he gives much it is because he undertakes to do himself what had better be left to experts. . . . His duty is not to administer, but to supervise and direct the administration.

It is precisely this adjustment between the professional and lay elements in the government which has been responsible for the marked success of the English borough governments. As in the commission plan the legislative and administrative powers of the English borough are vested in the council, which is the sole governing authority. The actual work of administration is carried on by a permanent staff of experts acting under the supervision and control of standing committees of the council. As the commissioner of police overlooks the police department in the commission-governed city, so the watch committee supervises the police administration of the English borough. In the same manner the library and school boards of American cities have been for several years supervising with distinct success the permanent corps of experts in charge of the public libraries and schools. Thus we are not compelled to subscribe to any new or untried principle in advocating municipal administration by a permanent staff of experts working under the direction of elective laymen.

The principle underlying the organization of the commission system of city government is clearly in harmony with what American and English experience has shown to be the most effective working principle that may be applied to the government of cities in a democracy. The commissioner, being an elective official, can not be expected to be an expert official. Indeed, experts will never accept an office of such uncertain tenure as that subject to the fluctuating influence of politics. The commissioner may be an efficient unprofessional, *supervisory* official, however, acting in the same capacity as the English council committee: and in such a capacity he will reach his maximum efficiency. Under this clearly defined distribution of functions between the elective and the permanent official each official will exercise that kind of function for which he is best fitted. This proposition, clearly understood, settles the crucial point in the problem of commission government.

If the commissioner's function is defined as supervisory with respect to his relation to the administrative service, the question may arise: Will it not now become necessary to have a permanent expert department head working under the supervising commissioner? This question must be decided with reference to the character of the commissioner's duties. In the small city, where the affairs of the different divisions of the department are left to the charge of the subordinate officials, these duties would be comparatively light, and only the general direction of the activities should rest with the commissioner. Under such circumstances the commissioner would be able to direct the work without the aid of a permanent head. It is probable, on the other hand, that the work of directing one of the great departments of the very large city would be too onerous and too complex for the layman to discharge without the aid of a permanent administrative head, in which case it would be found necessary to institute the permanent official.

When it has become definitely understood that the proper functions of the commission are legislative and *supervisory,* and not legislative and *administrative,* charter framers desiring to construct upon the commission model will have a well-understood basis upon which to work, and questions which frequently perplex them at the present time will take care of themselves. For example, one of the mooted questions at present is whether the commissioner would be required to give his whole time or only a part of it. If by the charter expected to spend his whole time in the public service, obviously he is to become an active superintendent, attending to the numerous details of his department, so that any other occupation than that of the city would entail negligence and inefficiency.

With the development of the commission plan into a more distinctly supervisory character, the American people will have worked

out a system of city government which does not differ in essential principles from that with which they started out, the council plan. The machinery of the commission government is more centralized and more responsive, but the relation between the elective official and the permanent administrative staff is common to both systems. It is upon these principles that the permanent efficiency of the commission government must rest, just as it was contempt for these principles that caused the failure of the reform municipal systems of the past thirty years. If the commission plan conforms strictly to these principles, there is reason to believe that it will not become the subject of a tale "full of sound and fury, signifying nothing."

GENIUS AND HAIR-COLOR

By CHARLES KASSEL
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OF the physiognomy of man—so interesting in its every phase—no feature can boast a more varied interest than the hair. Remnant of the coarse fur which once covered the body of the human animal—withdrawn at last, after a losing battle with time, to its invincible retreat and stronghold upon the head—this relic of beast life grew with the process of the suns into a thing of use and meaning,—a mark of race, an emblem of rank, a symbol of religion, and lastly, but chief of all, into an adornment of surpassing beauty affording to Cupid a most potent weapon in his merry warfare against the sons and daughters of men.

The place of the hair in the religious life of the race has been unique. Among the Greeks and Romans, the hair, worn long until the fourteenth year, was then severed from the youth's head and dedicated to a river-god; and the sailors of both these countries, after a shipwreck or other dire calamity at sea, thought it a fitting propitiation of the angered deities to remove and cast away the hair. It is highly noteworthy that not only in the Roman Catholic and Hindu churches, but throughout nearly all the ancient world, the tonsure in one form or another was a sacred rite. This was true of the vestal virgins as it has been true of the Roman Catholic nuns and monks, and a like custom among the Tartars of old survives in the queue of the Chinese.

As a mark of honor the hair in the old time played no less distinctive a part. To the ancient Persians, Goths and Gauls, long, flowing locks spoke of high rank, and among the ancient Germans the same adornment told of noble or royal birth. Even so lately as the reign of Henry VIII. in England long hair was a token of gentility, and readers may still recall the love-locks of the cavaliers of Charles I.—an amiable vanity which was given short shrift by their Puritan victors.

Seeing the large place which the hair has filled in the religious and social life of the race, it is in no wise remarkable that the fancy of mankind should have sought to attach to that feature of the physiognomy a much deeper meaning. Thus, in all ages, stiff and wiry hair has been deemed a sign of dishonesty or low birth, while softly clustering curls humanity has ever been prone to associate with gentleness and innocence. Coarse hair has been looked upon as a sign of a coarse organization, but the "poet's ringlets" have always formed a part of the popular conception of the poetic character.

In a general way, the well-known facts of ethnology have given a

semblance of support to theories of character based upon the color and structure of the hair. The characteristics of the hair not only form one of the leading tests of nationality, but there is a fairly well-marked difference between the hair of the lower and that of the higher races. In Huxley's celebrated classification of mankind, those peoples low in the scale of development are marked by black hair, usually straight, though sometimes of close spiral form—as, the Australoid, represented by the natives of Australia and the indigenous tribes of southern India,—the Negroid, dwelling between the Sahara and the Cape,—and the Mongoloid, occupying a vast area in Asia. Among the loftier races, on the other hand—the Xanthachroic, or fair whites, and Melanchroic, or dark whites, in Huxley's terminology—the former, occupying northern Europe as their chief seat though traceable also into northern Africa and eastward as far as Hindostan, have hair ranging from straw color to chestnut, and the latter, consisting chiefly of the Celts and of the populations of southern Europe, though finding representatives as far as India, have hair darkening from the middle shades to black; the hair of both of these types, however, as is well known, being usually wavy or curly.

In the coarseness of the hair the lower peoples probably betray their greater nearness in point of development to the animal ancestor of man, since the crown hair of the anthropoid brute—the chimpanzee, gorilla, orang-utan and gibbon—is of stiff, bristling structure. Nor can we say it is unsafe to infer the condition of man's progenitor in this respect from that of the modern apes, since, aside from all other proofs, there is a striking and peculiarly persuasive circumstance which shows how much of interest to the evolutionist lies hidden away within the cells and pigment-granules of the hair. It is invariably true with man, according to writers upon the subject, that if the beard and head hair vary in color the former is of lighter shade—a number of authorities add "generally reddish"—and this strange fact is equally true of the anthropoid apes, with whom the beard is often white, sometimes yellow or reddish; and this analogy with the anthropoids applies not only to the lower human races, with whom, as with the apes, the beard is scanty—it applies as well to the highest human races, with whom fulness of beard is a mark of racial superiority. In color, too, the hair of the anthropoid appears to show a kinship with that of the lower human tribes. The head hair of the chimpanzee is black, sometimes shot through with reddish hairs—that of the gorilla is reddish-brown, as a rule, though sometimes dark brown or even black—that of the orang is reddish-brown, though sometimes dark, with the beard occasionally dark yellow—that of the gibbon is usually a glossy black. While it is true that the lower races in Huxley's classification have been marked by black hair and that the hair of the apes is as to some species dark and as to others reddish, yet it is significant that the differ-

ence is no greater, and it is even more significant that among the anthropoid brutes no instance of fair head hair is known, just as no instance is known of blue or gray eyes. As regards, moreover, the hair color of the lower races of man in relation to that of the apes it is well to keep in mind the statement of Quatrefages in "The Human Species" that there are "isolated cases in all races of individuals with hair of more or less reddish color."

The favorable and unfavorable auguries, however, in which the folk-wisdom of mankind has indulged have dealt more in detail than science has sanctioned with the characteristics of the hair. Thus, in nearly all countries popular superstition has looked askance at red hair. Yellow hair, too, has never in the proverbs of nations been conspicuously associated with talent or deep character. In the ancient tapestries, Judas and Cain are pictured with yellow beards. Fair hair, strangely enough, has not figured in popular maxim as the accompaniment of great constancy of purpose. More often to brown or chestnut hair has this tribute been paid, and indeed most of the other virtues ascribed. Black hair, notwithstanding its association with the lower races, has not been deemed an unhappy omen, where fine and abundant, though straight, and the lighter shades of red in women—auburn and golden—are often, where the hair is soft, linked in folklore with great steadiness of purpose and an unfaltering loyalty in love. These generalizations, however, it should be said, are made up from a loose article upon "Hair" as found in a rather crude "Encyclopedia of Superstitions and Folklore" printed in three volumes some years ago—no really authentic work upon the folklore of physiognomy being published so far as the present writer has been able to ascertain.

It is of more than passing interest that the facts of criminology should afford quite marked support to the view which would look upon the hair as an index to racial development. "The proportion of dark-haired persons," says Havelock Ellis, one of our highest authorities, in "The Criminal," "is considerably greater among criminals than among the ordinary populations in England, Italy and America," and he adds, "The beard in criminals is usually scanty. On the head the hair is usually, on the contrary, abundant. Marro has observed a considerable proportion of wooly-haired persons—a character very rarely found in normal individuals. The same character has been noted among idiots. Among criminal women remarkable abundance of hair is frequently noted and it has sometimes formed their most characteristic physical feature accompanied by an unusual development of fine hair on the face and body." As to the predominant hair-color among criminals authorities do not agree. Even as to the general statement that the hair-color of criminals is commonly darker than that of the normal man authorities are not altogether in agreement, for Dr. Charles E. Woodruff, of the United States Army—himself a painstaking worker

in this field—announces it as his opinion, in the *Medical Record* for August 7, 1909, that in America, at least, "the criminal is more often fair than dark." This but gives point to the observation of Ellis that "to the existing statistics of the color of hair among criminals, taken as a whole, it is not possible at present to attach much value. There is no uniform system of description or nomenclature; it is difficult to make full allowance for ethnic divergence and there rarely exists an adequate standard of comparison for normal persons of corresponding race."

It is, however, not in the use of the hair as a social and religious symbol, nor in its aspect as a mark of race or token of criminality that the inquiry in hand makes its highest appeal. It is in the relation of the form and color of the hair to talent and genius that the absorbing interest of this subject lies. Is it the light-haired or the dark-haired person who is likeliest to display marked power of intellect? Does straight or spiral hair point most often to capacity? Do soft and stiff hair speak the same or a varying message as to the character and mental endowments of the owner?

Upon this phase of the subject the decisive testimony must come from the pages of biography. Nothing less than a test of the question by the facts of life may fairly make a claim upon our time and attention. True it is that biographers have not always preserved for us these details of physiognomy, nor do biographers of the same individual always agree as to the points of figure and feature; yet enough exists that is authentic to serve as a basis for a few modest generalizations.

Seeing the predominance of blue and gray and bluish-gray eyes among persons of distinction, as determined in the discussion of physiognomy as related to genius in the February issue, 1911, of this magazine, it might have seemed just to expect that the hair-color of eminent men would be fair. In reality, however, the case is otherwise. The hair-color of celebrated personages, in so far as the result of our investigation may justify us in speaking, has usually been dark.

Classified as "dark" we find the hair of Browning, Rufus Choate, Alexander Dumas the elder, Wm. Hazlitt (another authority says black) Washington Irving (other authorities say "chestnut brown"), Landor, Francis Parkman, Rossetti, R. L. Stevenson, Martin Van Buren, Tennyson and Mendelssohn, the hair of the last being almost black.

As possessed of black hair we have the names of Matthew Arnold, S. T. Coleridge, Stephen A. Douglas, Sir Thomas More (black shot with yellow), Wm. Hazlitt (another authority says "dark"), Leigh Hunt (shining black), Ibsen, Paul Jones, Charles Lamb, John Marshall, Washington Alston, Daniel Webster, J. G. Whittier, Sir Arthur Sullivan.

Given as brown we have the hair of William Cullen Bryant (dark

brown), Charles XII. of Sweden (dark brown), Captain Cook (dark brown), Cromwell, Defoe (dark brown), Longfellow, Farragut (becoming in middle life almost black), Dean Farrar (dark brown), Eugene Field (cross between brown and *dove* color!), Gladstone (brown, later black), Gordon, U. S. Grant (reddish brown, though another authority says chestnut brown), Keats (gold brown), Sidney Lanier (light brown), Napoleon (dark brown), Washington Irving (chestnut), John Milton (light brown), Peter the Great (ruddy brown), George Ripley, Robespierre, John Ruskin, Shelley, Southey, Charles Sumner (nut brown), Bayard Taylor (dark brown), Thoreau, General Thomas (light brown), George Washington (light brown) though another authority says dark brown), N. P. Willis (light brown).

The remainder of the names in our list, aside from the case of Thackeray, whose hair is described sometimes as "white" and sometimes as "flaxen," we have classed as "reddish." The hair of Bunyan is so described, that of Andrew Jackson is described as "reddish sandy," that of James Russell Lowell as "ruddy" or "auburn," that of Swinburne as "red" in his youth, though the information in this last case comes from a passing reference in a magazine article and not from an authoritative biography. William the Silent is described as having auburn hair and Savanarola as having reddish eyelashes, while Thomas Hobbes is referred to as having yellowish-reddish whiskers. It will be remembered that in an earlier portion of this paper the hair of U. S. Grant is given as reddish-brown and that of Peter the Great as ruddy-brown. The case of Swinburne is thus the single instance of red hair in our lists if our information as to that individual is authentic. As to Hobbes it is important to note that the color given refers only to the beard which, under the law we have mentioned, must have been lighter in color than the head hair, and it is not improbable therefore that the hair of Hobbes was dark.

The absence of yellow from our lists is highly important, seeing that flaxen is the leading hair color of the northern races of Europe. The hair of Sir Thomas More, as we have seen, was "black shot with yellow," and as to R. L. Stevenson it is said "his hair, from being light, almost yellow, became after twenty-five dark but not black." The hair of Thackeray, as already mentioned, is spoken of sometimes as "white" and sometimes as "flaxen." These aside, however, we are without the name of a single individual whose hair is described unqualifiedly as "yellow," unless the case of Thackeray be taken as such.

More interesting, however, than the detail of color is the structure of the hair among men of genius. Upon this phase of the subject our data lend marked sanction to a popular fancy mentioned in an early paragraph of this paper. The "poet's ringlets" seem to represent a distinct fact in biography. Of the sixty individuals whose hair is described in our data the structure of the hair is given as to twenty-six,

and of these twenty-two possessed curly or wavy hair. It is an interesting circumstance that of these twenty-two personages no less than nineteen were poets, artists or literary men, namely: Dumas the elder, Hazlitt, Leigh Hunt (inclined to wave), Charles Lamb, Washington Alston, Tennyson (wavy), Sir Arthur Sullivan (wavy), Mendelssohn (very curly), Gladstone, Keats (clustering and curly), Lanier (wavy, almost straight), Ruskin, Shelley, Southey, Bayard Taylor, N. P. Willis, Chopin, Thackeray. In the entire list of eminent men possessing curly or wavy hair only General Thomas, Martin Van Buren (wavy), Charles George Gordon (crisp and wavy) can not be classed as poets, artists or literary men. Hair of marked softness or fulness seems likewise a frequent accompaniment of artistic and literary genius. Thus the hair of Washington Alston is referred to not only as curly but as "silken," that of Rossetti as "silken and abundant," that of Eugene Field as "very fine," that of Keats as "clustering thickly," that of Lanier as "soft," that of Ruskin as "luxuriant," and that of Sumner as a "rich mass." The abundant hair of musicians, as observed upon the concert platform, will in this connection suggest itself to the reader.

Those in the list of twenty-six whose hair was straight were Daniel Webster, James Russell Lowell, Grieg and Napoleon, and of these the hair of Napoleon is spoken of as "stiff and flat," that of Andrew Jackson as "stiff and wiry," and that of Lowell as "wiry." We have seen that the hair of Lowell was of a very unpoetic color, and that biographer who insisted Lowell had not the poet's nose might have included the hair in his remark, alike as to its color and formation. In view of the prejudice in all ages against coarse, bristling hair the personal qualities of Napoleon and Andrew Jackson are not unworthy of note in connection with the structure of the hair in those cases, and the Indian-like hair of Webster, perhaps, we may associate with the coarse strain that betrayed itself not infrequently in the character of that distinguished personage; but the wiry hair of Lowell is a warning against too hasty a generalization, and the straight hair of Grieg may read to us a valuable lesson against carrying too far the notion that wavy hair is the unfailing accompaniment of artistic genius.

In the paper of the present writer upon "Genius and Stature" in the December issue, 1910, of this magazine, the conclusion was reached that the stature of genius is in general above the medium, and in the discussion of physiognomy and genius, as already mentioned, it was determined that the eyes of genius are usually blue or gray or bluish gray. Thus far, therefore, genius would seem to abide chiefly with the class of humanity called by Huxley the "Xanthachroic," with their tall stature and blue or gray eyes; but the hair of that type ranges from straw-color to chestnut, whereas the hair of genius, as we have seen, is in the very large majority of cases dark. Dark hair, it will be recalled, is a characteristic of the Melanchroic in Huxley's classification—who

otherwise, however, have no distinct kinship with genius since they are low of stature relatively to the fair whites and possess dark eyes.

Beyond this it may be safe so far to generalize as to declare that individuals of artistic or literary genius in general possess wavy or curly hair, and that even in the case of genius it is not amiss to look for a coarse organization where the hair is coarse and stiff. If, moreover, our data may be relied upon, red and yellow hair rarely accompany genius.

It must be confessed, however, after all is said, that anything beyond tentative conclusions seem forbidden by the scantiness of the data available upon this subject. The inattention of many biographers to the details of personal appearance is a blighting obstacle in inquiries of this nature, and, even where present in works of biography, the absence of adequate indexes makes the task of gathering this information tedious and painful. The fact, moreover, of the predominance of American and English names, and the presence of names of merely accidental distinction, or of mere eminence instead of genius, hinders the usefulness of the average library as an agency for research of this character, and the want of authentic data as to the physical traits of the average individual of the several nationalities but adds to the difficulties of the investigator. The all-important desideratum, be it said, is a list carefully sifted from the catalogue of the world's great names, sufficiently large and discriminating to reduce to the minimum the proportion of names of merely accidental or local note yet gathered by such method as to fairly represent all nationalities. This supplied and the worker furnished as to each nationality with reliable data respecting the details of stature and physiognomy of the average individual, research of truly scientific character would be possible. No better list of names, perhaps, could be desired, as a starting point for research, than the thousand names submitted by Professor Cattell in The Popular Science Monthly for February, 1903, as representing the world's most famous persons, carefully gathered as that list was from the biographical encyclopedias of America and Europe, though even as to this list of names the distinction between men of mere eminence and men of true genius would need to be constantly kept in mind. Nothing short, however, of investigation based upon such a catalogue of names—an investigation, it is plain, which only the amplest library facilities would permit—could be productive of results that might be regarded as final.

In the meanwhile the importance of the subject itself is not to be belittled. As said by Professor Cattell at the outset of the article we have mentioned, "It is now time that great men should be studied as a part of social evolution and by methods of exact and statistical science." This is being done as regards the criminal, and assuredly genius has no less a claim upon the time and talents of our workers.

A CONSIDERATION OF THE NATURE OF HUNGER[1]

By Professor W. B. Cannon

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"WHY do we eat?" This question, presented to a group of educated people, is likely to bring forth the answer, "We eat to compensate for body waste, or to supply the body with fuel for its labors." Although the body is in fact losing weight continuously and drawing continuously on its store of energy, and although the body must periodically be supplied with fresh material and energy in order to keep a more or less even balance between the income and the outgo, this maintenance of weight and strength is not the motive for taking food.

Primitive man, and the lower animals, may be regarded as quite unacquainted with notions of the equilibrium of matter and energy in the body, and yet they take food and have an efficient existence, in spite of this ignorance. In nature, generally, important processes, such as the preservation of the individual and the continuance of the race, are not left to be determined by intellectual considerations, but are provided for in automatic devices. Natural desires and impulses arise in consciousness, driving us to action; and only by analysis do we learn their origin or divine their significance. Thus our primary reasons for eating are to be found, not in convictions about metabolism, but in the experiences of appetite and hunger.

Appetite and Hunger

The sensations of appetite and hunger are so complex and so intimately interrelated that any discussion is sure to go astray unless at the start there is clear understanding of the meanings of the terms. The view has been propounded that appetite is the first degree of hunger, the mild and pleasant stage, agreeable in character; and that hunger itself is a more advanced condition, disagreeable and even painful—the unpleasant result of not satisfying the appetite.[2] On this

[1] Presented to the Harvey Society, New York City, December 16, 1911. The results here stated were published in the *American Journal of Physiology*, 1912, XXIX., pp. 41–454.

[2] Bardier, Richet's "Dictionnaire de Physiologie," article "Faim," 1904, VI., p. 1. See, also, Howell, "Text-book of Physiology," fourth edition, Philadelphia and London, 1911, p. 285.

basis appetite and hunger would differ only quantitatively. Another view, which seems more justifiable, is that the two experiences are fundamentally different.

Careful observation indicates that appetite is related to previous sensations of taste and smell of food. Delightful or disgusting tastes and odors, associated with this or that edible substance, determine the appetite. It has therefore important psychic elements in its composition, as the studies by Pawlow and his collaborators have so clearly shown. Thus, by taking thought, we can anticipate the odor of a delicious beefsteak or the taste of peaches and cream, and in that imagination we can find pleasure. In the realization, direct effects in the senses of taste and smell give still further delight. We now know from observations on experimental animals and on human beings, that the pleasures of both anticipation and realization, by stimulating the flow of saliva and gastric juice, play a highly significant rôle in the initiation of digestive processes.[3]

Among prosperous people, supplied with abundance of food, the appetite seems sufficient to ensure for bodily needs a proper supply of nutriment. We eat because dinner is announced, because by eating we avoid unpleasant consequences, and because food is placed before us in delectable form and with tempting tastes and odors. Under less easy circumstances, however, the body needs are supplied through the much stronger and more insistent demands of hunger.

The sensation of hunger is difficult to describe, but almost every one from childhood has felt at times that dull ache or gnawing pain referred to the lower mid-chest region and the epigastrium, which may take imperious control of human actions. As Sternberg has pointed out, hunger may be sufficiently insistent to force the taking of food which is so distasteful that it not only fails to rouse appetite, but may even produce nausea. The hungry being gulps his food with a rush. The pleasures of appetite are not for him—he wants quantity rather than quality, and he wants it at once.

Hunger and appetite are, therefore, widely different—in physiological basis, in localization and in psychic elements. Hunger may be satisfied while the appetite still calls. Who is still hungry when the tempting dessert is served, and yet are there any who refuse it, pleading they no longer need it? On the other hand, appetite may be in abeyance while hunger is goading.[4] What ravenous boy is critical of his food? Do we not all know that "hunger is the best sauce"? Although the two sensations may thus exist separately, they, nevertheless, have

[3] Pawlow, "The Work of the Digestive Glands," London, 1902, pp. 50, 71.

[4] See Sternberg, *Zentralblatt für Physiologie*, 1909, XXII., p. 653. Similar views were expressed by Bayle in a thesis presented to the Faculty of Medicine in Paris in 1816.

the same function of leading to the intake of food, and they usually appear together. Indeed the cooperation of hunger and appetite is probably the reason for their being so frequently confused.

The Sensation of Hunger

In the present paper we shall deal only with hunger. The sensation may be described as having a central core and certain more or less variable accessories. The peculiar dull ache of hungriness, referred to the epigastrium, is usually the organism's first strong demand for food; and when the initial order is not obeyed, the sensation is likely to grow into a highly uncomfortable pang or gnawing, less definitely localized as it becomes more intense. This may be regarded as the essential feature of hunger. Besides the dull ache, however, lassitude and drowsiness may appear, or faintness, or violent headache, or irritability and restlessness such that continuous effort in ordinary affairs becomes increasingly difficult. That these states differ much with individuals —headache in one, and faintness in another, for example—indicates that they do not constitute the central fact of hunger, but are more or less inconstant accompaniments, and need not for the present engage our attention. The "feeling of emptiness," which has been mentioned as an important element of the experience,[5] is an inference rather than a distinct datum of consciousness, and can likewise be eliminated from further consideration. The dull pressing sensation is left, therefore, as the constant characteristic, the central fact, to be examined in detail.

Hunger can evidently be regarded from the psychological point of view, and discussed solely on the basis of introspection; or it can be studied with reference to its antecedents and to the physiological conditions which accompany it—a consideration which requires the use of both objective methods and subjective observation. This psychophysiological treatment of the subject will be deferred till the last. Certain theories which have been advanced with regard to hunger and which have been given more or less credit must first be examined.

Two main theories have been advocated. The first is supported by evidence that hunger is a general sensation, arising at no special region of the body, but having a local reference. This theory has been more widely credited by physiologists and psychologists than the other. The other is supported by evidence that hunger has a local source and therefore a local reference. In the course of our examination of these views we shall have opportunity to consider some pertinent new observations.

[5] See Hertz, "The Sensibility of the Alimentary Canal," London, 1911, p. 38.

The Theory that Hunger is a General Sensation

The conception that hunger arises from a general condition of the body rests in turn on the notion that, as the body uses up material, the blood becomes impoverished. Schiff advocated this notion, and suggested that poverty of the blood in food substance affects the tissues in such manner that they demand a new supply. The nerve cells of the brain share in this general shortage of provisions, and because of internal changes, give rise to the sensation.[6] Thus is hunger explained as an experience dependent on the body as a whole.

Three classes of evidence are cited in support of this view.

1. *"Hunger Increases as Time Passes"—a Partial Statement.*—The development of hunger as time passes is a common observation which quite accords with the assumption that the condition of the body and the state of the blood are becoming constantly worse, so long as the need, once established, is not satisfied.

While it is true that with the lapse of time hunger increases as the supply of body nutriment decreases, this concomitance is not proof that the sensation arises directly from a serious encroachment on the store of food materials. If this argument were valid we should expect hunger to become more and more distressing until death. There is abundant evidence that the sensation is not thus intensified; on the contrary, during continued fasting hunger wholly disappears after the first few days. Luciani, who carefully recorded the experience of the faster Succi, states that after a certain time the hunger feelings vanish and do not return.[7] And he tells of two dogs that showed no signs of hunger after the third or fourth day of fasting; thereafter they remained quite passive in the presence of food. Tigerstedt, who also has studied the metabolism of starvation, declares that although the desire to eat is very great during the first day of the ordeal, the unpleasant sensations disappear early, and that at the end of the fast the subject may have to force himself to take nourishment.[8] The subject, "J. A.," studied by Tigerstedt and his co-workers, reported that after the fourth day of fasting, he had no disagreeable feelings.[9] Carrington, after examining many persons who, to better their health, abstained from eating for different periods, records that "habit-hunger" usually lasts only two or three days and, if plenty of water is drunk, does not last longer than three days.[10] Viterbi, a Corsican lawyer, condemned to death for political causes, determined to escape execution by depriving

[6] Schiff, "Physiologie de la digestion," Florence and Turin, 1867, p. 40.

[7] Luciani, "Das Hungern," Hamburg and Leipzig, 1890, p. 113.

[8] Tigerstedt, Nagel's "Handbuch der Physiologie," Berlin, 1909, I., p. 376.

[9] Johanson, Landergren, Sonden and Tigerstedt, *Skandinavisches Archiv für Physiologie*, 1897, VII., p. 33.

[10] Carrington, "Vitality, Fasting and Nutrition," New York, 1908, p. 555.

his body of food and drink. During the eighteen days that he lived he kept careful notes. On the third day the sensation of hunger departed, and although thereafter thirst came and went, hunger never returned.[11] Still further evidence of the same character could be cited, but enough has already been given to show that after the first few days of fasting the hunger feelings cease. On the theory that hunger is a manifestation of bodily need, are we to suppose that, in the course of starvation, the body is mysteriously not in need after the third day, and that therefore the sensation of hunger disappears? The absurdity of such a view is obvious.

2. *"Hunger may be Felt though the Stomach be Full"—a Selected Alternative.*—Instances of duodenal fistula in man have been carefully studied, which have shown that a modified sensation of hunger may be felt when the stomach is full. A famous case described by Busch has been repeatedly used as evidence. His patient, who lost nutriment through the fistula, was hungry soon after eating, and felt satisfied only when the chyme was restored to the intestine through the distal fistulous opening.[12] As food is absorbed mainly through the intestinal wall, the inference is direct that the general bodily state, and not the local conditions of the alimentary canal, must account for the patient's feelings.

A full consideration of the evidence from cases of duodenal fistula can not so effectively be presented now as later. That in Busch's case hunger disappeared while food was being taken is, as we shall see, quite significant. It may be that the restoration of chyme to the intestine quieted hunger, not because nutriment was thus introduced into the body, but because the presence of material altered the nature of intestinal activity. The basis for this suggestion will be given in due course.

3. *"Animals may Eat Eagerly after Section of their Vagus and Splanchnic Nerves"—a Fallacious Argument.*—The third support for the view that hunger has a general origin in the body is derived from observations on experimental animals. By severance of the vagus and splanchnic nerves, the lower œsophagus, the stomach and the small intestine can be wholly separated from the central nervous system. Animals thus operated upon nevertheless eat food placed before them, and may indeed manifest some eagerness for it.[13] How is this behavior to be accounted for—when the possibility of local stimulation has been eliminated—save by assuming a central origin of the impulse to eat?

The fallacy of this evidence, though repeatedly overlooked, is easily

[11] Viterbi, quoted by Bardier, *loc. cit.*, p. 7.

[12] Busch, *Archiv für pathologische Anatomie und Physiologie und für klinische Medicin*, 1858, XIV., p. 147.

[13] See Schiff, *loc. cit.*, p. 37; also Ducceschi, *Archivio di fisiologia*, 1910, VIII., p. 579.

shown. We have already seen that appetite as well as hunger may lead to the taking of food. Indeed, the animal with all gastrointestinal nerves cut may have the same incentive to eat that a well-fed man may have, who delights in the pleasurable taste and smell of food and knows nothing of hunger pangs. Even when the nerves of taste are cut, as in Longet's experiments,[14] sensations of smell are still possible, as well as agreeable associations which can be roused by sight. More than fifty years ago Ludwig pointed out that, even if all the nerves were severed, psychic reasons could be given for the taking of food,[15] and yet because animals eat after one or another set of nerves is eliminated, the conclusion has been drawn by various writers that the nerves in question are thereby proved to be not concerned in the sensation of hunger. Evidently, since hunger is not required for eating, the fact that an animal eats is no testimony whatever that the animal is hungry, and therefore, after nerves have been severed, is no proof that hunger is of central origin.

Weakness of the Assumptions Underlying the Theory that Hunger is a General Sensation.—The evidence thus far examined has been shown to afford only shaky support for the theory that hunger is a general sensation. The theory, furthermore, is weak in its fundamental assumptions. There is no clear indication, for example, that the blood undergoes, or has undergone, any marked change, chemical or physical, when the first stages of hunger appear. There is no evidence of any direct chemical stimulation of the gray matter of the cerebral cortex. Indeed, attempts to excite the gray matter artificially by chemical agents have been without results;[16] and even electrical stimulation, which is effective, must, in order to produce movements, be so powerful that the movements have been attributed to excitation of underlying white matter rather than cells in the gray. This insensitivity of cortical cells to direct stimulation is not at all favorable to the notion that they are sentinels set to warn against too great diminution of bodily supplies.

Body Need may Exist without Hunger.—Still further evidence opposed to the theory that hunger results directly from the using up of organic stores is found in patients suffering from fever. Metabolism in fever patients is augmented, body substance is destroyed to such a degree that the weight of the patient may be greatly reduced, and yet the sensation of hunger under these conditions of increased need is wholly lacking.

Again, if a person is hungry and takes food, the sensation is sup-

[14] Longet, "Traité de physiologie," Paris, 1868, I., p. 23.

[15] Ludwig, "Lehrbuch der Physiologie des Menschen," Leipzig and Heidelberg, 1858, II., p. 584.

[16] Maxwell, *Journal of Biological Chemistry*, 1906–7, II., p. 194.

pressed soon afterwards, long before any considerable amount of nutriment could be digested and absorbed, and therefore long before the blood and the general bodily condition, if previously altered, could be restored to normal.

Furthermore, persons exposed to privation have testified that hunger can be temporarily suppressed by swallowing indigestible materials. Certainly scraps of leather and bits of moss, not to mention clay eaten by the Otomacs, would not materially compensate for large organic losses. In rebuttal to this argument the comment has been made that central states as a rule can be readily overwhelmed by peripheral stimulation, and just as sleep, for example, can be abolished by bathing the temples, so hunger can be abolished by irritating the gastric walls.[17] That comment is beside the point, for it meets the issue by merely assuming as true the condition under discussion. The absence of hunger during the ravages of fever, and its quick abolition after food or even indigestible stuff is swallowed, still further weakens the argument, therefore, that the sensation arises directly from lack of nutriment in the body.

The Theory that Hunger is of General Origin does not Explain the Quick Onset and the Periodicity of the Sensation.—Many persons have noted that hunger has a sharp onset. A person may be tramping in the woods or working in the fields, where fixed attention is not demanded, and without premonition may feel the abrupt arrival of the characteristic ache. The expression "grub-struck" is a picturesque description of this experience. If this sudden arrival of the sensation corresponds to the general bodily state, the change in the general bodily state must occur with like suddenness or have a critical point at which the sensation is instantly precipitated. There is no evidence whatever that either of these conditions occurs in the course of metabolism.

Another peculiarity of hunger, which I have noticed in my own person, is its intermittancy. It may come and go several times in the course of a few hours. Furthermore, while the sensation is prevailing, its intensity is not uniform, but marked by ups and downs. In some instances the ups and downs change to a periodic presence and absence without change of rate. In making the above statements I do not depend on my own introspection alone; psychologists trained in this method of observation have reported that in their experience the temporal course of the sensation is distinctly intermittent.[18] In my own experience the hunger pangs came and went on one occasion as follows:

[17] See Schiff, *loc. cit.*, p. 49.

[18] I am indebted to Professor J. W. Baird, of Clark University, and his collaborators, for this corroborative testimony.

Came	Went	Came	Went
12–37–20	38–30	43–20	43–35
40–45	41–10	44–40	45–55
41–45	42–25	46–15	46–30

and so on, for ten minutes longer. Again in this relation, the intermittent and periodic character of hunger would require, on the theory under examination, that the bodily supplies be intermittently and periodically insufficient. During one moment the absence of hunger would imply an abundance of nutriment in the organism, ten seconds later the presence of hunger would imply that the stores had been suddenly reduced, ten seconds later still the absence of hunger would imply a sudden renewal of plenty. Such zig-zag shifts of the general bodily state may not be impossible, but from all that is known of the course of metabolism, such quick changes are highly improbable. The periodicity of hunger, therefore, is further evidence against the theory that the sensation has a general basis in the body.

The Theory that Hunger is of General Origin does not Explain the Local Reference.—The last objection to this theory is that it does not account for the most common feature of hunger—namely, the reference of the sensation to the region of the stomach. Schiff and others who have supported the theory[19] have met this objection by two contentions. First they have pointed out that the sensation is not always referred to the stomach. Schiff interrogated ignorant soldiers regarding the local reference; several indicated the neck or chest, twenty-three the sternum, four were uncertain of any region, and two only designated the stomach. In other words, the stomach region was most rarely mentioned.

The second contention against the importance of local reference is that such evidence is fallacious. An armless man may feel tinglings which seem to arise in fingers which have long since ceased to be a portion of his body. The fact that he experiences such tinglings and ascribes them to dissevered parts, does not prove that the sensation originates in those parts. And similarly the assignment of the ache of hunger to any special region of the body does not demonstrate that the ache arises from that region. Such are the arguments against a local origin of hunger.

Concerning these arguments we may recall, first, Schiff's admission that the soldiers he questioned were too few to give conclusive evidence. Further, the testimony of most of them that hunger seemed to originate in the chest or region of the sternum can not be claimed as unfavorable to a peripheral source of the sensation. The description of feelings which develop from disturbances within the body is almost always indefinite. As Head and others have shown, conditions in a viscus which give rise to sensation are likely not to be attributed to the viscus,

[19] See Schiff, *loc. cit.*, p. 31; Bardier, *loc. cit.*, p. 16.

but to related skin areas.[20] Under such circumstances we do not dismiss the testimony as worthless merely because it may not point precisely to the source of the trouble. On the contrary, we use such testimony constantly as a basis for judging internal disorders.

With regard to the contention that reference to the periphery is not proof of the peripheral origin of a sensation, we may answer that the force of that contention depends on the amount of accessory evidence which is available. Thus if we see an object come into contact with a finger, we are justified in assuming that the simultaneous sensation of touch which we refer to that finger has resulted from the contact, and is not a purely central experience accidentally attributed to an outlying member. Similarly in the case of hunger—all that we need as support for the peripheral reference of the sensation is proof that conditions occur there, simultaneously with hunger pangs, which might reasonably be regarded as giving rise to those pangs.

Objections to Some Theories that Hunger is of Local Origin

With the requirement in mind that peripheral conditions be adequate, let us examine the state of the fasting stomach to see whether indeed conditions may be present in times of hunger which would sustain the theory that hunger has a local outlying source.

Hunger not Due to Emptiness of the Stomach.—Among the suggestions which have been offered to account for a peripheral origin of the sensation is that of attributing it to emptiness of the stomach. By use of the stomach tube Nicolai found that when his subjects had their first intimation of hunger the stomach was quite empty. But, in other instances, after lavage of the stomach, the sensation did not appear for intervals varying between one and a half and three and a half hours.[21] During these intervals the stomach must have been empty, and yet no sensation was experienced. The same testimony was given long before by Beaumont, who, from his observations on Alexis St. Martin, declared that hunger arises some time after the stomach is normally evacuated.[22] Mere emptiness of the organ, therefore, does not explain the phenomenon.

Hunger not Due to Hydrochloric Acid in the Empty Stomach.—A second theory, apparently suggested by observations on cases of hyperacidity, is that the ache or pang is due to hydrochloric acid secreted into the stomach while empty. Again the facts are hostile. Nicolai reported that the gastric wash-water from his hungry subjects was neutral or only slightly acid.[23] This testimony confirms Beaumont's

[20] Head, *Brain*, 1893, XVI., p. 1; 1901, XXIV., p. 345.

[21] Nicolai, "Ueber die Entstehung des Hungergefühls," Inaugural-Dissertation, Berlin, 1892, p. 17.

[22] Beaumont, "The Physiology of Digestion," second edition, Burlington, 1847, p. 51.

[23] Nicolai, *loc. cit.*, p. 15.

statement, and is in complete agreement with the results of gastric examination of fasting animals reported by numerous experimenters. There is no secretion into the empty stomach during the first days of starvation. Furthermore, persons suffering from absence of hydrochloric acid (achylia gastrica) declare that they have normal feelings of hunger. Hydrochloric acid can not therefore be called upon to account for the sensation.

Hunger not Due to Turgescence of the Gastric Mucosa.—Another theory, which was first advanced by Beaumont, is that hunger arises from turgescence of the gastric glands.[24] The disappearance of the pangs as fasting continues has been accounted for by supposing that the gastric glands share in the general depletion of the body, and that thus the turgescence is relieved.[25] This turgescence theory has commended itself to several recent writers. Thus Luciani has accepted it, and by adding the idea that nerves distributed to the mucosa are specially sensitive to deprivation of food he accounts for the hunger pangs.[26] Also Valenti declared two years ago that the turgescence theory of Beaumont is the only one with a semblance of truth in it.[27] The experimental work reported by these two investigators, however, does not necessarily sustain the turgescence theory. Luciani severed the previously exposed vagi after cocainizing them, and Valenti merely cocainized the nerves; the fasting dogs, eager to eat a few minutes previous to this operation, now ran about as before, but when offered food, licked and smelled it, but did not take it. This total neglect of the food lasted varying periods up to two hours. The vagus nerves seem, indeed, to convey impulses which affect the procedure of eating, but there is no clear evidence that those impulses arise from distention of the gland cells. The turgescence theory, moreover, does not explain the effect of taking indigestible material into the stomach. According to Pawlow, and to others who have observed human beings, the chewing and swallowing of unappetizing stuff does not cause any secretion of gastric juice.[28] Yet such stuff when swallowed will cause the disappearance of hunger, and Nicolai found that the sensation could be abolished by simply introducing a stomach sound. It is highly improbable that the turgescence of the gastric glands can be reduced by either

[24] Beaumont, *loc. cit.*, p. 55.

[25] A better explanation perhaps is afforded by Boldireff's discovery that at the end of two or three days the stomachs of fasting dogs begin to secrete gastric juice and continue the secretion indefinitely. (Boldireff, *Archives biologiques de St. Petersburg*, 1905, XI., p. 98.)

[26] Luciani, *Archivio di fisiologia*, 1906, III., p. 54. Tiedemann long ago suggested that gastric nerves become increasingly sensitive as fasting progresses. ("Physiologie des Menschen," Darmstadt, 1836, III., p. 22.)

[27] Valenti, *Archives italiennes de biologie*, 1910, LIII., p. 94.

[28] Pawlow, *loc. cit.*, p. 70; Hornborg, *Skandinavisches Archiv für Physiologie*, 1904, XV., p. 248.

of these procedures. The turgescence theory, furthermore, does not explain the quick onset of hunger, or its intermittent and periodic character. That the cells are repeatedly swollen and contracted within periods a few seconds in duration is almost inconceivable. For these reasons, therefore, the theory that hunger results from turgescence of the gastric mucosa can reasonably be rejected.

Hunger the Result of Contractions

There remain to be considered, as a possible cause of hunger-pangs, contractions of the stomach and other parts of the alimentary canal. This suggestion is not new. Sixty-six years ago Weber declared his belief that "strong contraction of the muscle fibers of the wholly empty stomach, whereby its cavity disappears, makes a part of the sensation which we call hunger."[29] Vierordt drew the same inference twenty-five years later (in 1871),[30] and since then Ewald, Knapp, and Hertz have declared their adherence to this view. These writers have not brought forward any direct evidence for their conclusion, though Hertz has cited Boldireff's observations on fasting dogs as probably accounting for what he terms "the gastric constituent of the sensation."[31]

The Empty Stomach and Intestine Contract.—The argument commonly used against the gastric contraction theory is that the stomach is not energetically active when empty. Thus Schiff stated "the movements of the empty stomach are rare and much less energetic than during digestion."[32] Luciani expressed his disbelief by asserting that gastric movements are much more active during gastric digestion than at other times, and cease almost entirely when the stomach has discharged its contents.[33] And Valenti stated only year before last "we know very well that gastric movements are exaggerated while digestion is proceeding in the stomach, but when the organ is empty they are more rare and much less pronounced," and therefore they can not account for hunger.[34]

Evidence opposed to these suppositions has been in existence for many years. In 1899, Bettmann called attention to the contracted condition of the stomach after several days' fast.[35] In 1902, Wolff reported that after forty-eight hours without food the stomach of the cat may be so small as to look like a slightly enlarged duodenum.[36] In a similar circumstance I have noticed the same extraordinary smallness of the organ, especially in the pyloric half. The anatomist His also recorded

[29] Weber, Wagner's "Handwörterbuch der Physiologie," 1846, III^2., p. 580.

[30] Vierordt, "Grundriss der Physiologie," Tübingen, 1871, p. 433.

[31] Knapp, *American Medicine*, 1905, X., p. 358; Hertz, *loc. cit.*, p. 37.

[32] Schiff, *loc. cit.*, p. 33.

[33] Luciani, *loc. cit.*, p. 542.

[34] Valenti, *loc. cit.*, p. 95.

[35] Bettmann, *Philadelphia Monthly Medical Journal*, 1899, I., p. 133.

[36] Wolff, Dissertation, Giessen, 1902, p. 9.

his observation of the phenomenon.[37] Six years ago Boldireff demonstrated that the whole gastro-intestinal tract has a periodic activity while not digesting.[38] Each period of activity lasts from 20 to 30 minutes, and is characterized in the stomach by rhythmic contractions 10 to 20 in number. These contractions, Boldireff reports, may be stronger than during digestion, and his published records clearly support this statement. The intervals of repose between periodic recurrences of the contractions lasted from one and a half to two and a half hours. Especially noteworthy is Boldireff's observation that if fasting is continued for two or three days, the groups of contractions appear at gradually longer intervals and last for gradually shorter periods, and thereupon, as the gastric glands begin continuous secretion, all movements cease.

Observations Suggesting a Relation Between Contractions and Hunger.—When Boldireff's paper was published I was studying auscultation of abdominal sounds. Repeatedly there was occasion to note that the sensation of hunger was, as already stated, not constant, but recurrent, and that its momentary disappearance was often associated with a rather loud gurgling sound, as heard through the stethoscope. That contractions of the alimentary canal on a gaseous content might explain the hunger pangs seemed probable at that time, especially in the light of Boldireff's observations. Indeed, Boldireff himself had considered hunger in relation to the activities he described, but solely with the idea that hunger might *provoke* them; and since the activities dwindled in force and frequency as time passed, whereas, in his belief they should have become more pronounced, he abandoned the notion of any relation between the phenomena.[39] Did not Boldireff misinterpret his own observations? When he was considering whether hunger might cause the contractions, did he not overlook the possibility that the contractions might cause hunger? A number of experiences have led to the conviction that Boldireff did, indeed, fail to perceive part of the significance of his results. For example, I have noticed the disappearance of a hunger pang as gas was heard gurgling upward through the cardia. That the gas was rising rather than being forced downward was proved by its regurgitation immediately after the sound was heard. In all probability the pressure that forced the gas from the stomach was the cause of the preceding sensation of hunger. Again the sensation can be momentarily abolished a few seconds after swallowing a small accumulation of saliva or a teaspoonful of water. If the stomach is in strong contraction in hunger, this result can be accounted for as due to the inhibition of the contraction by swallowing.[40] Thus also could be

[37] His, *Archiv für Anatomie*, 1903, p. 345.

[38] Boldireff, *loc. cit.*, p. 1.

[39] Boldireff, *loc. cit.*, p. 96.

[40] See Cannon and Lieb, *American Journal of Physiology*, 1911, XXIX., p. 267.

explained the prompt vanishing of the ache soon after we begin to eat, for repeated swallowing results in continued inhibition.[41] Furthermore, Ducceschi's discovery that hydrochloric acid diminishes the tonus of the pyloric portion of the stomach[42] may have its application here; the acid would be secreted as food is taken and would then cause relaxation of the very region which is most strongly contracted.

The Concomitance of Contractions and Hunger in Man.—Although the evidence above outlined had led me to the conviction that hunger results from contractions of the alimentary canal, direct proof was still lacking. In order to learn whether such proof might be secured, one of my students, Mr. A. L. Washburn, determined to become accustomed to the presence of a rubber tube in the œsophagus.[43] Almost every day for several weeks Mr. Washburn introduced as far as the stomach a small tube, to the lower end of which was attached a soft-rubber balloon about 8 cm. in diameter. The tube was thus carried about each time for two or three hours. After this preliminary experience the introduction of the tube, and its presence in the gullet and stomach, were not at all disturbing. When a record was to be taken, the balloon, placed just below the cardia, was moderately distended with air, and was connected with a water manometer ending in a cylindrical chamber 3.5 cm. wide. A float recorder resting on the water in the chamber permitted registering any contractions of the fundus of the stomach. On the days of observation Mr. Washburn would abstain from breakfast, or eat sparingly; and without taking any luncheon would appear in the laboratory about two o'clock. The recording apparatus was arranged as above described. In order to avoid the possibility of an artifact, a pneumograph, fastened below the ribs, was made to record the movements of the abdominal wall. Between the records of gastric pressure and abdominal movement, time was marked in minutes, and an electromagnetic signal traced a line which could be altered by pressing a key. All these recording arrangments were out of Mr. Washburn's sight; he sat with one hand at the key, ready whenever the sensation of hunger was experienced to make the current which moved the signal.

Sometimes the observations were started before any hunger was noted; at other times the sensation, after running a course, gave way to a feeling of fatigue. Under either of these circumstances there were no contractions of the stomach. When Mr. Washburn stated that he was hungry, however, powerful contractions of the stomach were invariably being registered. As in the experience of the psychologists, the sensations were characterized by periodic recurrences with free inter-

[41] The absence of hunger in Busch's patient while food was being eaten (see p. 295) can also be accounted for in this manner.

[42] Ducceschi, *Archivio per le Scienze Mediche*, 1897, XXI., p. 154.

[43] Nicolai (*loc. cit.*) reported that although the introduction of a stomach tube at first abolished hunger in his subjects, with repeated use the effects became insignificant.

vals, or by periodic accesses of an uninterrupted ache. The record of Mr. Washburn's introspection of his hunger pangs agreed closely with the record of his gastric contractions. Almost invariably, however, the contraction nearly reached its maximum before the record of the sensation was started (see Fig. 1). This fact may be regarded as evidence

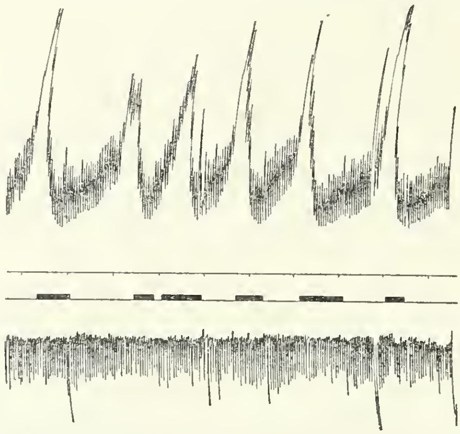


FIG. 1. One half the original size. The top record represents intragastric pressure (the small oscillations due to respiration, the large to contractions of the stomach); the second record is time in minutes (ten minutes); the third record is Mr. W.'s report of hunger pangs; the lowest record is respiration registered by means of a pneumograph about the abdomen.

that the contraction precedes the sensation, and not *vice versa,* as Boldireff considered it. The contractions were about a half-minute in duration, and the intervals between varied from thirty to ninety seconds, with an average of about one minute. The augmentations of intragastric pressure in Mr. Washburn ranged between 11 and 13 in twenty minutes; I had previously counted in myself eleven hunger pangs in the same time. The rate in each of us was, therefore, approximately the same. This rate is slightly slower than that found in dogs by Boldireff; the difference is perhaps correlated with the slower rhythm of gastric peristalsis in man compared with that in the dog.[44]

Before hunger was experienced by Mr. Washburn the recording apparatus revealed no signs of gastric activity. Sometimes a rather tedious period of waiting had to be endured before contractions occurred. And after they began they continued for a while, then ceased (see Fig. 2). The feeling of hunger, which was reported while the contractions were recurring, disappeared as the waves stopped. The inability of the subject to control the contractions eliminated the possibility of their being artifacts, perhaps induced by suggestion. The close concomitance of the contractions with hunger pangs, therefore, clearly indicates that they are the real source of those pangs.

Boldireff's studies proved that when the empty stomach is mani-

[44] See Cannon, *American Journal of Physiology,* 1903, VIII., p. xxi; 1905, XIV., p. 344.

festing periodic contractions, the intestines also are active. Conceivably all parts of the alimentary canal composed of smooth muscle share

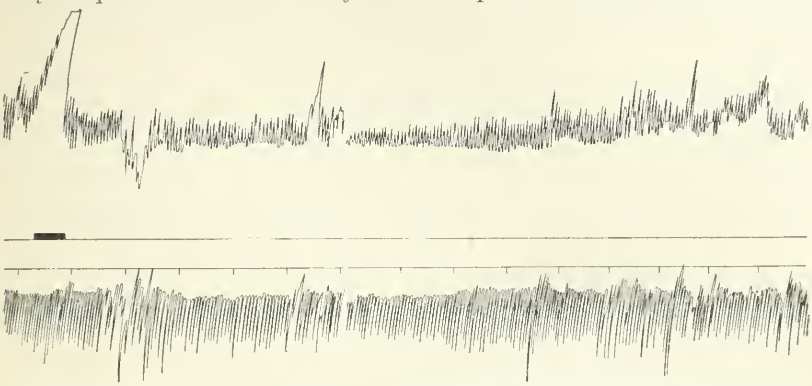


FIG. 2. One half the original size. The same conditions as in Fig. 1. (Fifteen minutes.) There was a long wait for hunger to disappear. After x, Mr. W. reported himself "tired but not hungry." The record from y to z was the continuance on a second drum of x to y.

in these movements. The lower œsophagus in man is provided with smooth muscle. It was possible to determine whether this region in Mr. Washburn was active during hunger.

To the œsophageal tube a thin-rubber finger-cot (2 cm. in length) was attached and lowered into the stomach. The little rubber bag was

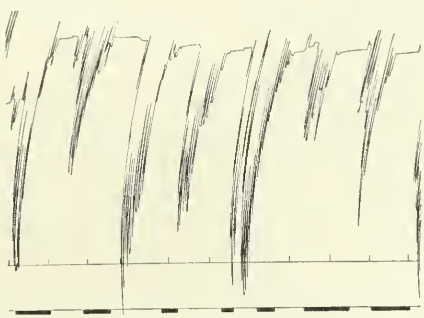


FIG. 3. One half the original size. The top record represents compression of a thin rubber bag in the lower œsophagus. The pressure in the bag varied between 9 and 13 cm. of water. The cylinder of the recorder was of smaller diameter than that used in the gastric records. The œsophageal contractions compressed the bag so completely that, at the summits of the large oscillations, the respirations were not registered. When the oscillations dropped to the time line, the bag was about half inflated. The middle line registers time in minutes (ten minutes). The bottom record is Mr. W.'s report of hunger pangs.

distended with air, and the tube, pinched to keep the bag inflated, was gently withdrawn until resistance was felt. The air was now released from the bag, and the tube further withdrawn about 3 cm. The bag was again distended with air at a manometric pressure of 10 cm. of water. Inspiration now caused the writing lever, which recorded the pressure changes, to rise; and a slightly further withdrawal of the tube changed the rise, on inspiration, to a fall. The former position of the tube, therefore, was above the gastric cavity and below the diaphragm. In this position the bag, attached to a float-recorder (with chamber

2.3 cm. in diameter), registered the periodic oscillations shown in Fig. 3. Though individually more prolonged than those of the stomach, these contractions, it will be noted, occur at about the same rate. It is probable that the periodic activity of the two regions is simultaneous, for otherwise the stomach would force its gaseous content into the œsophagus with the rise of intragastric pressure.

What causes the contractions to occur has not been determined. From evidence already given they do not seem to be directly related to bodily need. Habit no doubt plays an important rôle. For present considerations, however, it is enough that they do occur, and that they are abolished when food, which satisfies bodily need, is taken into the stomach. By such indirection, as already stated, are performed some of the most fundamental of the bodily functions.

Peculiarities of Hunger Explained by Contractions.—If these contractions are admitted as the cause of hunger, most of the difficulties confronting other explanations are readily obviated. Thus the occurrence of hunger at meal times is most natural, for, as the regularity of defecation indicates, the alimentary canal has habits. Activity returns at the usual meal time as the result of custom. By taking food regularly at a definite hour in the evening for several days, a new hunger period can be established. Since at these times the œsophagus and the empty stomach strongly contract, hunger is aroused.

The contractions furthermore explain the sudden onset of hunger and its peculiar periodicity—phenomena which no other explanation of hunger can account for. The quick development of the sensation after taking a cold drink is possibly associated with the well-known power of cold to induce contraction in smooth muscle.

The great intensity of hunger during the first day of starvation, and its gradual disappearance till it vanishes on the third or fourth day, are made quite clear, for Boldireff observed that the gastric contractions in his fasting dogs went through precisely such alterations of intensity, and were not seen after the third day.

In fever, when bodily material is being most rapidly used, hunger is absent. Its absence is understood from an observation reported four years ago, that infection, with systemic involvement, is accompanied by a total cessation of all movements of the alimentary canal.[45] Boldireff observed that when his dogs were fatigued the rhythmic contractions failed to appear. Being "too tired to eat" is thereby given a rational explanation.

Another pathological form of the sensation—the inordinate hunger (bulimia) of certain neurotics—is in accordance with the well-known disturbances of the tonic innervation of the alimentary canal in such individuals.

[45] Cannon and Murphy, *Journal of the American Medical Association*, 1907, XLIX., p. 840.

Since the lower end of the œsophagus, as well as the stomach, contracts periodically in hunger, the reference of the sensation to the sternum by the ignorant persons questioned by Schiff was wholly natural. The activity of the lower œsophagus also explains why, after the stomach has been removed, or in some cases when the stomach is distended with food, hunger can still be experienced. Conceivably the intestines also originate vague sensations by their contractions. Indeed the final banishment of the modified hunger sensation in the patient with duodenal fistula, described by Busch, may have been due to the lessened activity of the intestines when chyme was injected into them.

The observations recorded in this paper have, as already noted, numerous points of similarity to Boldireff's observations on the periodic activity of the alimentary canal in fasting dogs. Each period of activity, he found, comprised not only wide-spread contractions of the digestive canal, but also the pouring out of bile, and of pancreatic and intestinal juices rich in ferments. Gastric juice was not secreted at these times; when it was secreted and reached the intestine, the periodic activity ceased.[46] What is the significance of this extensive disturbance? Recently evidence has been presented that gastric peristalsis is dependent on the stretching of gastric muscle when tonically contracted.[47] The evidence that the stomach is in fact strongly contracted in hunger —*i. e.*, in a state of high tone—has been presented above.[48] Thus the very condition which causes hunger and leads to the taking of food is the condition, when the swallowed food stretches the shortened muscles, for immediate starting of gastric peristalsis. In this connection the recent observations of Haudek and Stigler are probably significant. They found that the stomach discharges its contents more rapidly if food is eaten in hunger than if not so eaten.[49] Hunger, in other words, is normally the signal that the stomach is contracted for action; the unpleasantness of hunger leads to eating; eating starts gastric secretion, distends the contracted organ, initiates the movements of gastric digestion, and abolishes the sensation. Meanwhile pancreatic and intestinal juices, as well as bile, have been prepared in the duodenum to receive the oncoming chyme. The periodic activity of the alimentary canal in fasting, therefore, is not solely the source of hunger pangs, but is at the same time an exhibition in the digestive organs of readiness for prompt attack on the food swallowed by the hungry animal.

[46] Boldireff, *loc. cit.*, pp. 108–111.

[47] Cannon, this journal, 1911, XXIX., p. 250.

[48] The "empty" stomach and œsophagus contain gas (see Hertz, *Quarterly Journal of Medicine*, 1910, III., p. 378; Mikulicz, "Mittheilungen aus dem Grenzgebieten der Medicin und Chirurgie," 1903, XII., p. 596). They would naturally manifest rhythmic contractions on shortening tonically on their content.

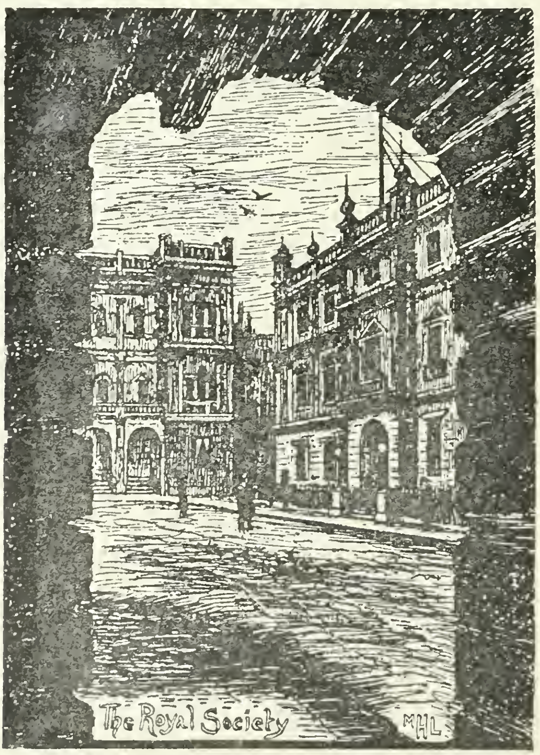
[49] Haudek and Stigler, *Archiv für die gesammte Physiologie*, 1910, CXXXIII., p. 159.

THE PROGRESS OF SCIENCE

THE TWO HUNDRED AND FIFTIETH ANNIVERSARY OF THE ROYAL SOCIETY

THE charter of the Royal Society of London was signed on July 15, 1662, and exactly two hundred and fifty years thereafter the event has been adequately celebrated. The organization of society in Great Britain makes social functions more successful than they are with us, and the events of the celebration were social rather than scientific. They consisted of a service in Westminster Abbey; a formal reception of the delegates at the rooms of the society in Burlington House; a banquet at the Guild Hall, when toasts were proposed by the prime minister, Lord Morley and the Archbishop of Canterbury; a conversazione at Burlington House; receptions by the king and queen and other entertainments, and the conferring of degrees at Oxford and Cambridge. There were present 132 foreign delegates from universities and learned societies, among whom the United States were represented by 23.

The Royal Society was established at nearly the same time as the Paris

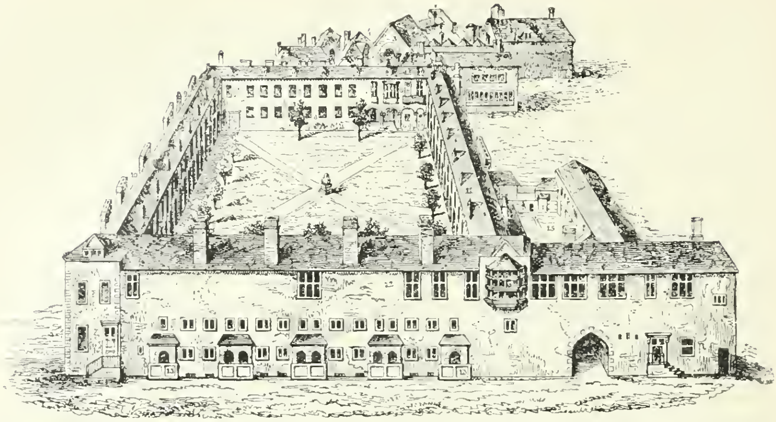


BURLINGTON HOUSE, from a drawing by Lady Huggins.

THE PRINCIPAL LIBRARY OF THE ROYAL SOCIETY.

Academy, and the two societies were unrivaled centers of scientific productivity, until the development of the German universities in the nineteenth century. It is remarkable how large a proportion of the men, from Newton to Darwin, who have originated new movements and new epochs in science have been members of the Royal Society. It is difficult to say to what extent the society has been responsible for their performance. Shortly after his election, Newton wrote to the secretary: "I desire that you will procure that I may be put out from being any longer Fellow of the Royal Society." Later he was for many years president, but at that time he was master of the mint and engaged in writing on subjects such as "The Prophecies of Daniel and the Apocalypse of St. John." Darwin presented his paper "On the Tendency of Species to form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection" to the Linnean Society, and but rarely attended the meetings of the Royal Society.

At the commemoration dinner, Mr. Asquith, the prime minister, said: "The society has not, I think, at any time had any direct financial assistance from the government. For this the government may be criticized; but I venture to think the society is to be congratulated. It is not well that science should be a mendicant for state endowment. I do not forget the annual grants for scientific research which are administered by the society; but



Old Gresham College, in which the meetings of the Royal Society were first held.

their administration is not a benefit conferred on the society by the state, but a service conferred on the state by the society.'' It is not clear why these sentiments should have been applauded by those present. In the first place they are not strictly correct. The society received £1,300 from King Charles and tried hard to get more. Indeed, the king granted them a share in the confiscated Irish estates, but the money failed to reach them. Apart from the annual grant of £4,000 to be awarded for scientific research, the government provides £1,000 for publications and the rooms in Burlington House. But why should the society be congratulated because it has received no government support? It was scarcely an advantage that Newton presented his resignation because he was unprepared to pay a shilling a week as dues, or that the society could not have made possible Darwin's work if he had needed assistance. The presidents of the society preceding Sir Archibald Geikie, Sir William Huggins and Lord Rayleigh, have been able to make their great contributions to science owing to their inherited wealth. The prime minister has been instrumental in paying members of parliament, because the old aristocratic methods no longer suffice. The fellows of the Royal Society contribute equally to the welfare of the state, and deserve equally to be paid for their services.

THE FIRST INTERNATIONAL EUGENICS CONGRESS

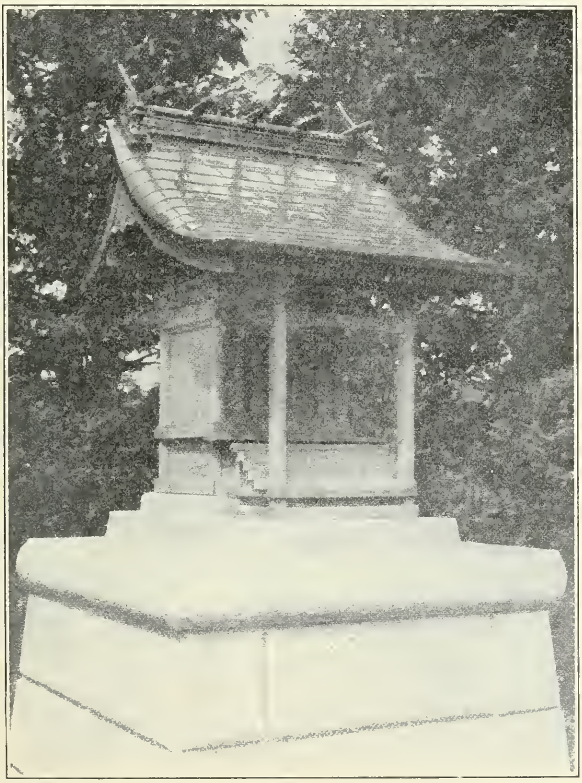
The First International Eugenics Congress has just been held in London. Its sittings ran from July 24 to July 30, and were better attended and more animated at the end than at the beginning. That is, their interest, both to delegates and general public, grew rather than diminished, which is an excellent augury for the next meeting.

This first congress can be truthfully called a success. Its organization and conduct, thanks to the London committees and its helpers, the sympathetic but firm presiding of Major Leonard Darwin, and the extraordinarily effective secretarial work of Mrs. S. Gotto, were wholly good. Delegates and readers came from eight nations, audiences of fair size attended all the sessions, and the London press reports were unexpectedly full and sympathetic. The hospitality shown the attendant delegates and readers of papers was of the best English type, than which there is admittedly no better. It is of interest to note, however, that of the largest and most elaborate three receptions tendered the delegates two

were given by American hostesses, namely, by the Duchess of Marlborough at Sunderland House and by Mrs. Whitelaw Reid at Dorchester House.

Thirty-one papers were presented before the congress, in English, French and Italian. The papers from German, Danish and Norwegian sources, as well most of those from Italian, were given in English. Of these thirty-one papers eight came from the United States, their authors being (in order of presentation of paper) Dr. Raymond Pearl, Dr. David F. Weeks, Dr. C. B. Davenport, Mr. Bleecker van Wagenen, Professor S. G. Smith, Professor V. L. Kellogg, Dr. Frederick Adams Woods and Professor H. E. Jordan. Dr. Weeks, Dr. Davenport and Professor Jordan were unable to be present, and their papers were read by their colleagues.

The decision as to the time and place of the next congress was deferred and will be made in August, 1913, by the permanent international committee, which has been provisionally organized subject to re-arrangement by the various national consultative committees. San Francisco presented an invitation to the committee to hold the next congress there in 1915 at the time of the Panama-Pacific Exposition, and the committee members are inclined to consider the invitation seriously. Dr. Ploetz, of Munich, president of the International Society for Race Hygiene, presented informally to the delegates a plan for the establishment of an international union of scientific race-hygiene and eugenics societies which



Shrine Erected at Tokyo in Memory of Robert Koch.

would be distinct from the international affiliation for the sake of holding popular congresses. The delegates seemed not wholly of one mind in regard to this. The American members of the international committee as at present provisionally organized are Messrs. van Wagenen, Woods, Pearl and Kellogg.

It will not be possible to present here ever so slight a report of the papers read at the congress, and of the no less important and animated discussions which most of these papers aroused. It must suffice to say that these papers ranged over a wide field of biologic, medical and sociologic study, with the subject of heredity ever being the special one chiefly in evidence. The papers and discussions ran also a long gamut between the extremely speculative and the extremely practical. But there was in most of them a gratifying tendency to hug closely the shore of real scientific ground. To different nations the term eugenics seems to have different nuances of meaning, but there is in them all a sufficient commonness to make desirable international consideration of eugenics problems.

The inauguration of this new series of international congresses is another witness of the growth of that best type of internationalism that leads scientific men to step unhesitatingly across political imaginary lines whenever they feel that they can work more effectively together than apart.

SCIENTIFIC ITEMS

We regret to record the death of M. Jules Henri Poincaré, the great mathematician and man of science; of M. Floris Osmond, eminent for his contributions to the metallurgy of steel, and of Mr. Andrew Lang, known for his contributions to anthropology as well as for his literary and critical work.

The presidents of the Royal Society and the Royal College of Surgeons have formed a large and representative committee for the purpose of establishing a memorial to the late Lord Lister.—A committee representing the engineering societies of the British Empire and the United States has been formed to carry into effect a proposal for the erection in Westminister Abbey of a memorial window to the late Lord Kelvin.

Professor Jeremiah W. Jenks, of Cornell University, has been appointed financial adviser to the Chinese republic.—Professor Charles Lincoln Edwards has been appointed naturalist of the Park Department of the City of Los Angeles, with the commission to plan a Zoological Park and Aquarium.

The following lectures will be delivered at the International Congress of Applied Chemistry to be held in New York in September: "The Rôle of the Infinitely Small in Biological Chemistry," by M. G. Bertrand, of Paris; "Oxidation of Atmospheric Nitrogen in Norway," by Dr. S. Eyde, of Christiania; "The Most Recent Problems of Chemical Industry," by Dr. C. Duisberg, of Elberfeld; "Permanent Fireproofing of Cotton Goods," by Professor W. H. Perkin, F.R.S., of Manchester; "Synthetic Ammonia," by Dr. H. A. Bernthsen, of Ludwigshafen; "The Photochemistry of the Future," by Mr. G. Ciamician, of Bologna, and "Priestley in America," by President Ira Remsen, of the Johns Hopkins University.

THE POPULAR SCIENCE MONTHLY.

OCTOBER, 1912

THE GUAYULE—A DESERT RUBBER PLANT[1]

By Professor F. E. LLOYD
MCGILL UNIVERSITY

PERHAPS no statement in regard to the source of our commercial rubbers is more surprising to one unacquainted with this particular field than that over 200 species of plants contribute to the sum total of the crude material which comes to the market. Indeed, that "rubber plant," which is frequently used as a household decoration is usually thought to be chiefly responsible, but this is far from the truth. This same rubber plant, however, furnishes us with a point of departure for the present account in the fact, well known to every one who has but slight acquaintance with it, that when injured, a milky fluid (latex) escapes, which, on drying, becomes translucent, and displays in some degree the familiar properties of india-rubber, or caoutchouc.

Diverse as are the plants which furnish caoutchouc, until a few years ago practically all of it was obtained by "tapping." This consists in cutting into the bark of the plant, and collecting either the milk (latex), to be coagulated immediately or later by various methods, or the strings and masses of coagulated latex adhering to the wound or elsewhere. Among the latex plants the only exception worthy of mention is the so-called grass or root rubber of the Congo. The rhizomes of the various species, which, because of their position, can not be tapped, are collected and dried, whereby the rubber is coagulated in the latex-tubes. It is subsequently extracted mechanically by heating, under such conditions as to separate the rubber from the fiber. It will appear evident that whenever the rubber exists as such within the plant, either as the result of coagulation or for any other reason, other methods than that of tapping must be resorted to for its extraction. The practise in the case of the root-rubbers suggest comminution of the

[1] For a full account see F. E. Lloyd, "Guayule, a Rubber Plant of the Chihuahuan Desert," Carnegie Institution of Washington, Publication 139.

tissues, accompanied by the agglomeration of the contained rubber. The methods of the chemist have suggested extraction by the use of suitable solvents, the rubber being recovered by differential solution and distillation of the solvents. Both these methods have been adapted to the extraction of rubber from the plant which shall claim brief attention in what follows.

I refer to the *guayule,* a low, gray or greenish-gray shrub (Figs. 1 and 2).

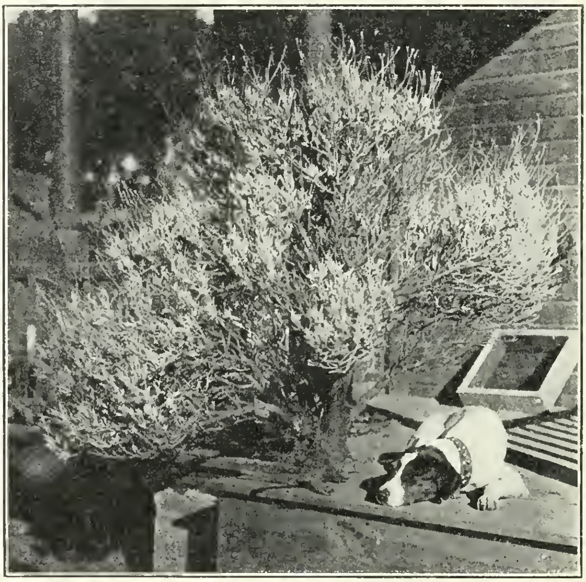


Fig. 1. A large and unusually symmetrical Guayule Plant.

of limited distribution within the Chihuahuan desert, having the center of its geographical area very near to the northern boundary of the state of Zacatecas, Mexico. The southern extension of this area lies somewhat below San Luis Potosi; to the north it is found in the Big Bend country of Texas; here are rather small amounts, and of low stature as compared with the conditions farther to the south. The plant scarcely invades the state of Sonora, and is found only in the western part of Nuevo Leon.

The chief interest attaching to its occurrence in Texas is the fact that it was here first discovered by Dr. J. M. Bigelow "near Escondido (Hidden) Creek." The party of the Mexican Boundary Survey, of which Bigelow was a member, in all probability rested at the large spring which forms the source of this creek, a camping-place for uncounted generations of Indians before the days of the white man. Here, on the McKenzie ranch, east of Fort Stockton, the writer also

camped, finding traces of earlier travelers in arrow-points, beads and old-fashioned army copper cartridge shells. On the surrounding slopes the guayule grows, and probably here Bigelow in 1852 found the specimen on which the description published by Asa Gray in 1859 was based.

For a good many years that specimen (Fig. 3) lay in the

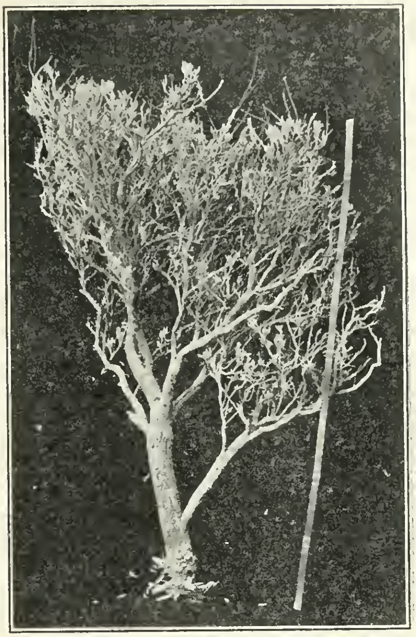


Fig. 2. A large Guayule Plant, probably 50 years old. The measure is one meter.

Fig. 3. The Specimen of the Guayule on which Asa Gray based his original description. After a photograph.

Gray Herbarium awaiting its apotheosis. So little was the plant known till recent years that even Bray does not mention it in his description of the vegetation of western Texas, written in 1906.

In fact, it was less than a year and a half previous to this date that, as the result of the efforts of Mr. William A. Lawrence, backed by American capital, it was for the first time demonstrated that it was possible to extract the rubber from the guayule by a mechanical process. On December 25, 1904, 50 pounds of crude guayule rubber were shipped to and sold in New York city. This was the beginning of the immense operations of the Continental-Mexican Rubber Co. at Torreón, Coahuila.

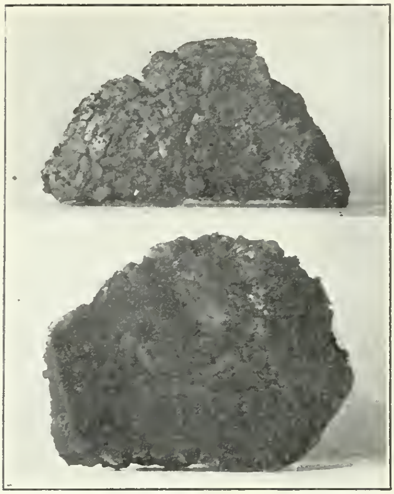


Fig. 4. Prehistoric Rubber found 14 Miles from Sasco, Arizona.

But the earlier history of the industry in Mexico has a larger romance than can well be related in the short space here allotted. The more salient points only may be mentioned. Just as the Mayas in the south, and in the Amazon region, made playing balls of latex rubber, so, in the north, guayule rubber was known and used by the aborigines. But the task of extraction was for these more indirect, for they chewed the bark of the plant, in order to separate out the fibrous tissue and to agglomerate the rubber. Assiduous mastication on the part of a sufficient number of devotees to pelota turned out in a short time a resilient if crude rubber ball. There is evidence that this plaything found its way by barter to the coast of the Gulf of California and probably the peoples to the north and east also obtained it. It is a matter of unusual interest that the aboriginal Papagos used rubber. Late in 1909 an *olla,* or earthenware jar, was unearthed at some depth on the site of an ancient village near Sasco, Ariz. In it were two round masses of rubber which, aside from a vitreous and fissured external layer, still displayed the texture, resiliency and odor of a dry and almost resin-free product. A generous piece (Fig. 5) of one of the masses was presented to the writer by Professor A. H. Forbes, of Tucson, Ariz., for study, but the microscopic evidence does not support the most natural supposition that it is guayule rubber, but more probably that it is a latex rubber which found its way northward from the more remote parts of Mexico. It is fairly certain, therefore, that rubber was an article of barter over a rather wide stretch of country.

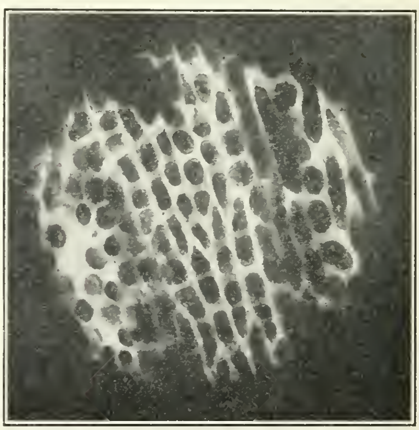


Fig. 5. Microscopic Appearance of Guayule Rubber in the Cells of the Rubber-bearing Tissue.

At the present time not only guayule, but two at least of its congeners, "*mariola*" (*Parthe-*

nium incanum) and "*tatanini*" (*Parthenium lyratum*) afford material to the hand of the ball enthusiast of northern Mexico. These two plants, however, contain rubber in very meager quantity as compared with guayule.

This method of extracting the rubber, *viz.*, by mastication, very naturally suggested the course of manufacture. As early as 1888 it was

Fig. 6. Flowers of Guayule.

proposed to extract the rubber "by a process of grinding and washing." A test carried out in New York by the interested company showed that the "bark" contained at least "18 per cent. rubber comparable to the best grade of centrals." But nothing further was done and samples sent about this time from Mexico to Germany and England, found no favor.

In 1900, however, some Germans established a laboratory at San Luis Potosi, the birthplace of the industry in Mexico. Two years later, as a result of the San Luis investigations, a factory was started at Jimulco, in which a method of extraction by solvents was used. It was at this time that the experimental operations carried on by Mr. Lawrence and leading to the practical solution of the mechanical method, culminated in the first commercial shipment of crude guayule rubber, extracted by mechanical means. This was the American and, indeed, most important contribution to the solution of the problem, and led, as above stated, to the establishment of the works of the Continental-Mexican Rubber Company.

That the rationale of the mechanical operations involved may be appreciated, we may now consider in some detail the structure of the plant.

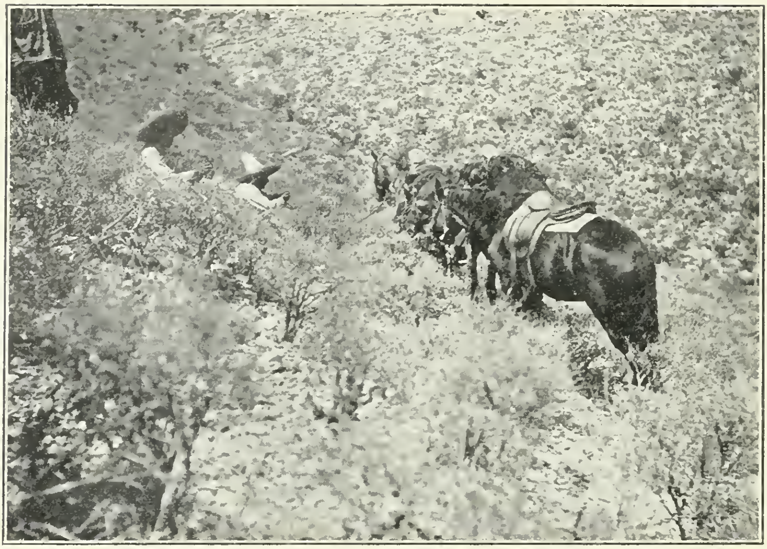


Fig. 7. Probably the best stand of Guayule in Mexico, Sierra Gojada, Dgo.

The guayule shrub, having the low, tree-like habit of many desert perennials, belongs to the family Compositæ of which our daisies and dandelions are familiar examples. The most obvious proof of this relationship is seen at once in the flowers, which, while not very daisy-like at first glance, are seen in somewhat closer examination to follow the same pattern. Instead, however, of the rather numerous white rays surrounding the yellow center of the well-known daisy, in the guayule the short rays are but five in number, and these, as well as the relatively large disc, are of a uniform pale, dullish yellow. The flowers, unusually for the Compositæ, have a distinct and very pleasing fragrance, and are visited, and incidentally pollinated, by various small insects, even mosquitoes. The leaves, which may or may not be lobed, according to their development, are clothed with a dense, smooth covering of T-shaped hairs, imparting to them the silvery sheen characteristic of the shrub as a whole.

The smaller twigs are similarly clothed, the hairiness giving way at length to a smooth gray bark, which, with advancing age, becomes longitudinally fissured. On the oldest and largest stems, transverse fissuring takes place. On the whole, however, the surfaces of the branches are smooth and gray, contributing to the general neutral aspect of the plant. But most striking of all the characters is the "feel" of the lesser branches when bent, suggesting a weak wooden rod encased in a firm rubber tube. The branches have little strength, the mechanical elements of the wood being relatively few. An examination of a

thin slice taken transversely through a smaller branch will enable us to gain some impression of the structure and especially of the manner of occurrence and distribution of the rubber. A twig about a year old taken at the end of a prolonged drought period will serve our purpose.

Referring to Fig. 9, the reader will note that several concentric zones of tissue appear. The outermost is cork (*ck*), which contains no measurable amount of rubber in small branches. In old thick stems the formation of cork in the deeper layers of the next occurring zone, the cortex (*cr* in the figure), results in the cutting out of rubber-bearing tissue, accompanied by a degeneration of the rubber itself, and its consequent loss. The cortex comes next. It is made up of cells of uniform size and shape, containing chlorophyll, and hence green in color. In each cell appears a large droplet of rubber, occupying nearly the whole of the interior space (Fig. 9). Here and there are oval openings which are sectional views of so many canals (*rc*) which traverse the cortex longitudinally. These contain a pale yellow resin, a commonly occurring material among the Compositæ. Any slight wound of the cortex, however caused, may open one or more of these canals, and the resin may then escape. Hardened, limpid drops of this, either clinging to the branches or fallen on the ground beneath, are always to be seen. The resin appears to be of little economic value, as it is soft. During the mechanical extraction of rubber, it becomes mixed with upwards of 20 per cent. resin.

Inwardly the cortex is broken up by radially placed masses of tissue partly composed of hard "bast" fibers (*bf*, Fig. 9). These correspond to the fibers of the flax in position and origin. Crude guayule rubber

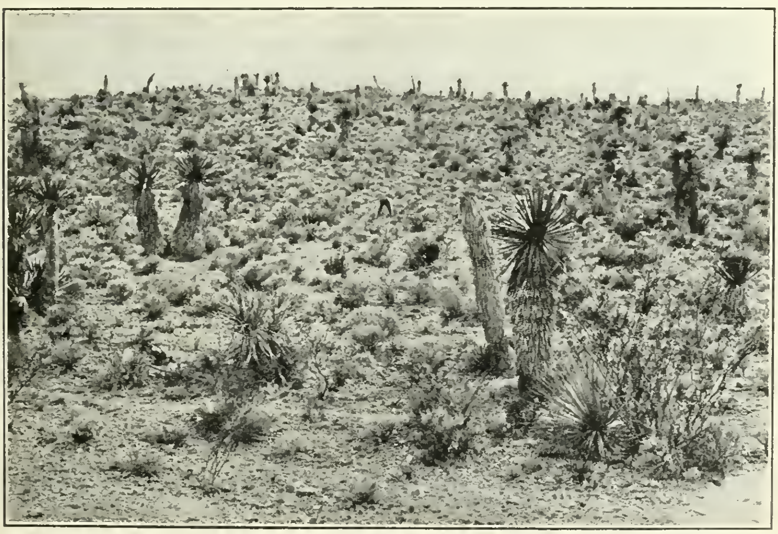


FIG. 8. AN ESPECIALLY FINE STAND OF GUAYULE NEAR LAS CAOPAS, ZACATECAS, MEXICO.

always contains fragments of minute fibers, single or in bundles, and, together with other fragments of cell walls, enable one to determine the origin of the rubber microscopically.

From the inner limit of the cortex, extending toward the center, are radial, wedge-shaped masses of wood (*w*, Fig. 9). This is composed of mechanical tissues with water vessels scattered irregularly throughout it. These may be identified by the width of their lumina. At the inner ends of the wood masses may occur additional bundles of "bast" fibers.

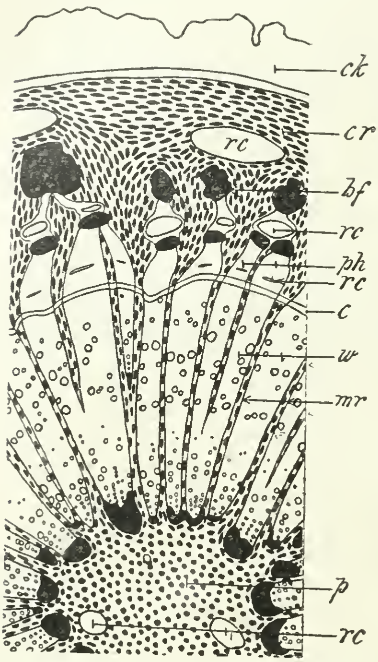


FIG. 9. SEMI-DIAGRAMMATIC SKETCH OF TWO-YEAR-OLD GUAYULE STEM IN TRANSVERSE SECTION.

The central area is occupied by the pith composed (*p* in the figure) of cells identical in every detail except in shape with those of the cortex. The pith cells are nearly circular in outline. They, too, contain rubber. Extending from the pith to the cortex and separating the wood bundles from each other, as also the bast bundles, are the so-called medullary rays (*mr*). Their cells, flattened tangentially, are otherwise quite like those of the cortex and pith, are equally rich in rubber. The pith, again like the cortex, is traversed longitudinally by resin canals. A point of interest here is that the canals with age become plugged by ingrowing masses of tissue, thus in a measure preventing the leakage of resin, especially in the cortex when invaded by cork. In the pith there is an undoubted downward leakage of resin, which, infiltrating into the older wood below, may be detected by chemical analysis. It is thus evident that the resin content of guayule wood is accidental.

By subsequent growth, year by year additional layers of bast and wood are laid down at the inner limit of the cortex, where the cambium, or actively growing tissue, is situated (*c*, Fig. 9). In the bast, and here alone, new resin canals are formed, in radial rows, therefore.

From this very curtailed description, it appears that, in the guayule, the rubber occurs as droplets—really very minute—each enclosed in a sac of albuminous material (protoplasm), this again surrounded by a sac of cellulose (the cell wall). All the cells of the pith, medullary

rays and cortex (and certain others which we need not mention here) contain rubber. There is no rubber in the canals, nor is there any rubber, or rather latex, vessels. It is for this reason that, while it is not possible to extract the rubber by tapping, it is possible, by comminution of tissues, to work together or agglomerate the minute particles of rubber set free by breaking the cells which hold them. It is equally evident that chemical agents may be used for extraction by solution, but this process is of less interest in this connection. We may now pass on to examine the methods of handling the shrub and the process of mechanical extraction.

Collecting the Shrub

The primary problem of collecting the shrub and transporting it to the factory is a difficult one. The shrub, growing wild, being contracted for, the purchaser is free to go and get it. This means that

Fig. 10. Hauling Guayule in Mexico.

peons must be hired to collect the plants in desert places often far removed from water and other supplies. They and their burros find their way into steep and rocky places unapproachable by other means. Having pulled up by the roots a *carga* of shrub, it is loaded on a burro and so off to a central camp, "*campo de guayule*," placed so as to be approachable by wagon. Here the shrub is baled after the fashion of so much hay. The bales are then hauled to the nearest railway station, sometimes 100 kilometers away, to be shipped to the factory.

Arrived there, the bales are weighed for comparison with the field weight. A certain amount of shrinkage is of course expected, owing to

the drying out of the shrub and breaking off of twigs. Since it was found possible to increase the field weight by methods devious and of little cost, thus selling stones or water at an exceptional price even in a country where that commodity is not cheap, a control by means of tags was devised, enabling a systematic comparison of the field and factory weights of shrub from all areas. The price of water quickly fell.

Manufacture

To keep a large plant running regularly a considerable reserve of shrub must be held. This was formerly stacked in the open, but later, when rapid deterioration was discovered, suitable storage warehouses were provided, thus obviating the deleterious action of the sun. When

Fig. 11. Packing Guayule Rubber at Torréon, Coahuilla.

the shrub is in good condition—that is, sufficiently, but not too dry—the bales are passed out to a washing floor where all dust and soil is removed by a stream of water. The importance of this becomes apparent when it is reflected that the rubber picks up particles of soil and its specific gravity altered, so making the separation of rubber and bagasse more difficult.

The shrub is now run between the steel rolls of a crusher which, running at differential speeds, grind up the plants into torn fragments. Peons take this material up in baskets and convey it to pebble mills. These are short iron cylinders which are arranged so as to rotate on their axes. Each mill is lined with flint bricks and is charged with ground shrub, water and coarse flint pebbles which by their impact on each other comminute the shrub and agglomerate the rubber. After

the milling is complete, which ensues after about 3,000 revolutions at the rate of 30 per minute, the mixture of water, comminuted shrub and bagasse is discharged and flows into skimming tanks. In these a portion of the bagasse, consisting of fibrous material (bast, wood) and fragments of other cell walls, sinks, while the agglomerated rubber ("worm rubber"), accompanied by a bagasse composed of minute flakes of cork, floats. This floating mixture can now be separated into practically clean worm rubber and rubber-free bagasse by boiling, and then by submitting it to a pressure of about 250 pounds under water, in order to water-log the cork flakes. A further cleansing of the worm rubber flakes takes place in a tank supplied with a paddle wheel, which beats the floating particles and so rids them of adherent particles. After this there remains but the "sheeting," which is accomplished by passing the worm rubber between corrugated steel rollers to form sheets. It may be packed in sacks in this form or pressed into solid blocks, say, of 50 pounds weight and packed in boxes. In this process it is evident that there are two critical phases, first the agglomeration of the rubber and, secondly, its later separation from the bagasse. The former is relatively easy or difficult, according to the richness of the tissues in rubber, or stated otherwise in the size of the rubber particles within the cells of the tissue. The separation of rubber from bagasse depends on the difference in their specific gravity, using this term in a loose sense. The fibrous elements, namely wood, bast and broken open cell walls, are easily waterlogged—that is, the occluded air is easily dispelled, while the cork is difficult to break up and even more so to rob of its air.

The coarse worm rubber floats rather readily; but the smaller the particles the more slowly they rise to the surface. Any means which may be used to cause a swelling of the particles, or to lessen the distance which they must travel to reach the surface, afford help in attaining to segregation of the rubber. The colloidal properties of rubber make swelling possible by means of any of its solvents. The depths of the tanks which are used for separation of rubber and bagasse is obviously important. When it is known that an extraction of 7 per cent. rubber (of which the moisture amounted to 25 per cent.) was raised during about five years to 15 per cent. by slowly improved methods, we may realize the amount of experiment and ingenuity necessary. It would have been well for the industry to-day if, during the earlier period, there had been less desire to take advantage of the ease of acquiring profit and more study and experiment. To be sure, a good deal of rubber left in the bagasse was later reclaimed, but the total lost in spite of this must have amounted to a good deal. This was, however, only one form of economic waste. By far the most serious lay in the method of gathering the shrub by pulling it up by the roots, called,

however, by the euphonious name of "*cortando*," or cutting. Had the guayule actually been cut off at the level of the ground, new shoots would have sprung up in many instances to take the place of the removed plants.

Reproduction of the Shrub

It has always been fully realized that the limiting factor of the guayule industry is the rate of growth and of natural reproduction of the "stand," unless the demand for shrub could be met by cultural methods. It is obvious that until the possibilities of culture could have been determined, the proper procedure would have been conservation of the mature supply by forestry methods. We may now examine the guayule plant from this point of view.

Fig. 12. The Annual Accretion of Growth in a Guayule Twig of average rate of growth.

The guayule is a woody shrub which, in common with most desert plants, is of slow growth under normal conditions. It affects the stony or rocky footslopes and foothills of the limestone hills and mountains within a region of uncertain and at best scanty rainfall. Few and imperfect records are available for the guayule region proper, but it is safe to say that the total precipitation does not exceed 10 or 12 inches. The effective rains fall chiefly in summer. The growth season is therefore short and the annual increment in growth in length of branches does not exceed an average of 3 to 5 cm. (Fig. 12). Plants certainly 50 years old do not exceed a meter in height or spread. I have never seen an old plant excelling in both dimensions. By careful measurements of numerous field plants it has been determined that it takes about 10 years for an individual to acquire a weight of about 8 ounces, but in the following five years it will make eight ounces more and will have ar-

rived at an economic maximum. It may then be concluded that assuming an even stand of a ton to the acre, it requires 15 acres to supply one ton a year, allowing for good years and bad. Most guayule land will not yield so well. It is, however, clear that where the land is very cheap and can be used for other profit to a considerable extent without materially damaging the shrub, a conservative method of gathering could have been made to yield reasonable and constant returns.

It has been assumed that the stand is maintained by the reproduction of guayule by seed. Field studies have shown that this is true. Areas of known dimensions have been cleared of all plant growth, and the new seedlings counted; and censuses have been taken of such areas to determine the population of plants of various ages. The information obtained proves clearly that the more usual method of reproduction is by seed. It must be added that different localities often not widely separated show a very diverse efficiency in this regard. Indeed, it has often been difficult to see any evidence that if the present growth were removed there would be any effectual replenishment by seed. Such places are marked by the absence of small seedlings and usually carry only mature individuals of approximately the same size. But it by no means follows that in such situations there is no reproduction at all, for in addition to seedlings the guayule also increases its members by means of "retoños," that is, by new shoots which strike upward from the shallow lying lateral roots. In the course of time retoños establish their own roots and become entirely separated from the rest of the plant and consequently independent organisms. Retoños grow more quickly than seedlings and are more certain of arriving at maturity. Because of the previous establishment of the root they may develop where, on account of slight depth of soil, seedlings would fail. As a matter of fact they are relatively more plentiful on rough stony ground and are particularly prone to occur where the surface of the ground is steep and the roots become exposed by erosion, though this is not a condition necessary to their formation. Furthermore, they develop flowers in the first season of their growth so that, in the event that the guayule were removed they would constitute a pretty certain insurance against extinction.

Whether the cutting away of the aerial portion of the plant induces the growth of retoños or not has not been decided, but, as already said, it is followed by abundant reproduction of new shoots from the stocks left in the soil. These follow cutting in about 40 per cent. of the cases, so far as determined, but as the year when the censuses were made was a dry one the figure is probably low for a good season. The time when the cutting takes place doubtless also influences the result. Aside from this, however, these new shoots develop rapidly, but flower abundantly in the first season and are thus effective in reseeding the ground.

We see, therefore, that the guayule is by no means unequipped for

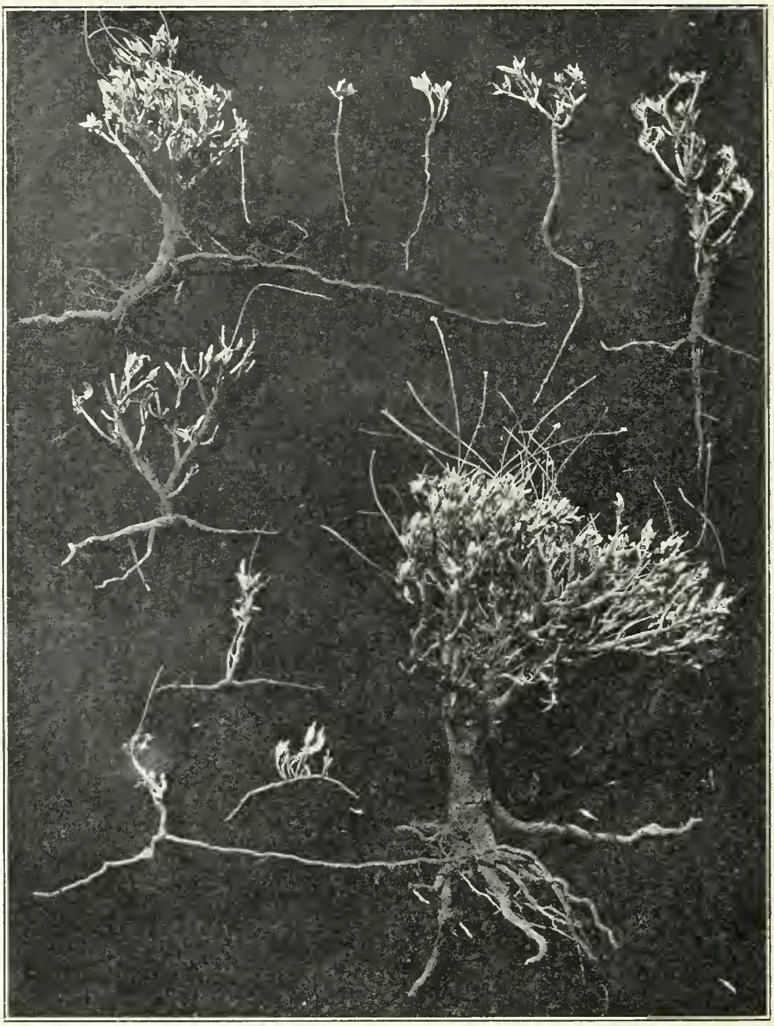


Fig. 13. The Development of the Guayule Plant from Seeds and from Retoños.

its business of obviating the effects of untoward conditions in its environment. We may now inquire briefly into its response to cultivation.

Guayule under Cultivation

To introduce a feral plant into a condition of culture is not without much uncertainty as to the results. The physiological balance is frequently so disturbed as to produce marked quantitative changes in the various secretions. Thus it happens that certain drug plants when put under cultural conditions do not always produce alkaloids or other

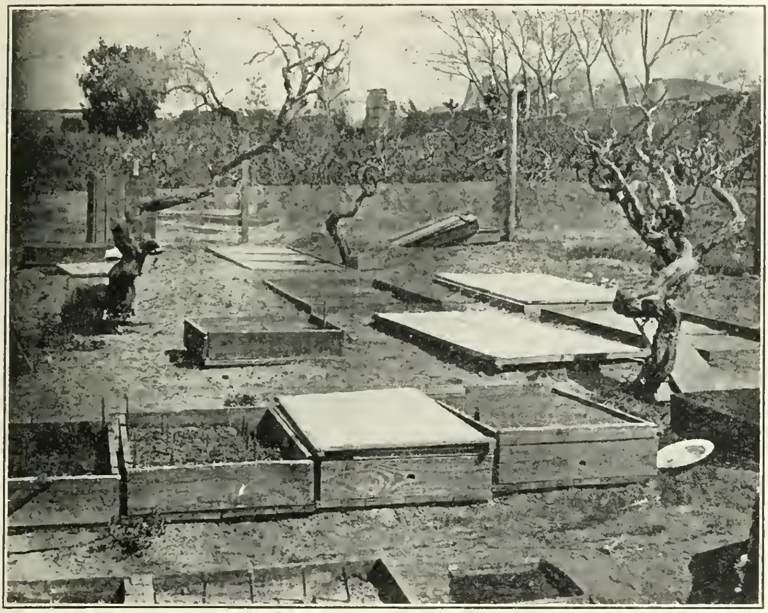


FIG. 14. EXPERIMENTAL GARDEN FOR THE STUDY OF REPRODUCTION OF GUAYULE, STACIENDE DE CEDROS, ZACATECAS.

FIG. 15. GUAYULE UNDER CULTIVATION IN AN EXPERIMENTAL GARDEN AT CEDROS, ZACATECAS, MEXICO.

desired substances in the same amount as in the wild. When the problem of cultivating the guayule presented itself, the first question that arose, and most naturally, was the relation of secretion of rubber to the supply of soil water. Though there is no very good *a priori* ground for expecting one result or the other, it was known that the amount of rubber obtained from certain latex trees is influenced by the amount of soil water during the period of tapping. It was also found that in the guayule the occurrence of rubber in the new growths of the particular season intervenes only after a distinct interval of time, for which reason the collecting of the shrub at the close of the rainy season involves a great waste, since the increased weight is in no degree to be referred to a greater rubber content.

The careful study of the guayule plants which were under cultivation and had been freely irrigated developed, in addition to several other points of interest, the knowledge that the greater the amount of growth (itself dependent on the amount of water available), the slower the secretion of rubber and the smaller its total amount relative to the volume of the tissues. On the other hand, the rate of growth under irrigation is so much more rapid that the total volume of rubber-bearing tissue is very greatly in excess of that in field plants. Irrigated plants present other features of difference which must be taken into account by the manufacturer and which are of very great interest to students of the physiology of desert plants. I need mention only the more salient here, namely, the greater relative volume of the woody portion of the stem, its harder and more rigid character, the smaller volume of the cortex (bark) (Fig. 16) and the quantity of rubber in individual secreting cells.

The increased hardness of the "wood" in the irrigated plant is due, in part at least, to the reduced volume of the medullary rays. And as

a *b* *c*

FIG. 16. TRANSVERSE SECTIONS OF GUAYULE STEMS, of the same transverse area of wood, grown under irrigation (*a*) and wild (*b*, *c*). *c* was from a plant of unusually rapid growth.

these make up a goodly proportion of the volume of the smaller twigs in the field plants, and since the medullary ray cells contain rubber, the greater hardness of the irrigated wood is attained at the cost of rubber-bearing tissue. The lessened volume of the cortex and of the pith contribute to the same results, so that even if the amount of rubber secreted by the individual cells remained unaffected by irrigation, the amount relative to the volume of the plant will be materially less. But so far as the writer's own observation goes the rubber cells in the plants which have been abundantly watered so as to extend the growing season over six or seven months, do not, even after subsequent sustained drought periods, contain the normal but rather a considerably less amount of rubber. This, from the point of view of the manufacturer, means that the globules of rubber which must be agglomerated into worm rubber in the pebble mill are smaller and farther apart and consequently more difficultly brought together. It means, too, that in obtaining a given amount of rubber much more bagasse must be handled. These difficulties may doubtless be overcome by suitable modifications in the details of the process already outlined.

The reader will have gathered the impression that the guayule may be grown readily under cultivation. This is true, at least in its areas of distribution and in adjacent or other areas of similar meteorological conditions. It does not, however, thrive in eastern Texas, judging from a specimen planted by Dr. H. H. York at Austin, nor in Alabama. Here it will grow rapidly the first season, but little the second. Further, a large percentage of the plants are killed by frost and dampness combined, whereas they will resist severe frost in dry regions. And again the amount of rubber in them is very small indeed. Why this peculiar relation of rubber secretion to soil water can not be said. The teleologist will doubtless see in rubber a means adapted to conservation of water in the desert plant. Field guayule, however, wilts almost immediately upon being pulled up, and its congener mariola, which is more drought-resistant, has even less rubber than irrigated guayule.

On the other hand, the larger development of the wood appears to be correlated with a more rapid growth, and consequently a larger production of leaves, made possible by a greater water supply. This logic is clearer when it is realized that the wood contains the water-carrying vessels and at the same time the mechanical tissue for the support of the foliage. From this point of view the more extensive rubber-bearing tissues and apparently greater succulence in field plants result from more meager development of the wood and do not speak for a larger "water balance," one criterion, at least, of drought resistance.

One additional feature of the behavior of guayule under irrigation, especially when grown from transplanted stocks, is worth mentioning in closing. It had been noticed that its congener, the mariola (*Par-*

thenium incanum), does not produce retoños, as does the guayule, but sends up each season new shoots from the base of the trunk. These shoots root independently and in the course of events are separated by a constriction of the connecting tissue from the parent plant so that an old mariola plant is really a cluster of partially or wholly independent individuals. Such behavior is absent from guayule under normal conditions, but may be readily induced under irrigation, and in this way there is afforded the means of vegetative propagation which stands in lieu of the usual method of making cuttings, which has not been found possible up to the present.

The question which many will ask, whether it will pay to cultivate guayule, must remain, for the present, unanswered. That guayule may be propagated under cultural conditions, both by seed and vegetatively, has been demonstrated. That there are immense areas adapted to guayule and now almost profitless is almost equally sure. The problem seems to be how to get the plant started and to determine to what extent temporary irrigation, by manipulation of the run-off, will be justified on practical economic grounds. An experiment of large scope could be conducted so as to answer these questions and might reveal a new means of increasing our resources.

ROUSSEAU'S CONTRIBUTIONS TO PSYCHOLOGY, PHILOSOPHY AND EDUCATION

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As is often the case with a great man viewed two centuries after his time, one is tempted to wonder what the source of Rousseau's repute may have been. Few men have so greatly influenced the course of thought in many different directions as Rousseau and few great men have been as little worthy of influence, judged by their characters or their attainments. It seems incredible that a vagabond, a psychopath, a man without serious training, should produce a system of philosophy, a system of education, a political philosophy, that was to modify the political systems as well as the course of thought of civilized nations for generations. To repeat a few cant phrases, Rousseau offers a paradox in each of his capacities between his theories and his actions. He preached social cooperation and the acceptance of social responsibilities, but was himself a hermit and recognized a duty only to avoid it; he praised social equality and the advantages of limiting one's desires rather than seeking means of satisfying them, but he spent his life fawning upon the great and the wealthy, and was always a parasite upon some one more fortunate than himself; in his system of education he gives much space to arguing the advantages of personal parental care for children, while he sent his own five children as soon as born to a foundling asylum, and with so little care that no one was able to trace them. Apparently the father was never sufficiently interested in their fate to make the attempt. The list might be expanded indefinitely, but this will amply suffice to show the inconsistencies of the man.

The key to his inconsistencies as to much of his power as a writer is to be found in his mental abnormalities. He was undoubtedly a psychasthenic all his life, and in his last years this probably passed over into insanity. The symptoms of psychasthenia are clear throughout his confessions. He was tortured always by the delirium of doubt, he was often aboulic, the sexual life that he portrays so fully gives much evidence of a Freudian neurasthenia; in his later life he was never without delusions of persecution. Nothing is lacking to complete the clinical picture. As one result of his mental disease he was never in complete control of either thought or action. He never could definitely and sharply pass upon the truth or falsity of his ideas. He lived all his life in a half-dream state, incapable of saying whether any one of the trains of ideas that presented itself was quite real, or was consistent with any other. To change the metaphor, his was a play life, through-

out. Each book and each chapter, even, of a book was a separate game with little relation to any other book or chapter or to the world of reality. It was consistent with that part, but had little or no relation to any thing beyond. He never grew up. In consequence he was never burdened by the adult necessity for consistency. Any act or any thought was true for the moment, and that was as far as he was capable of judging. The extent to which writing was a game for him is well illustrated, if we may believe Diderot, by the way he decided to take the most important stand of his life, that against art and science and all departures from nature. Diderot asserts that when Rousseau saw the topic that had been announced by the academy of Dijon in competition for a prize "Whether the progress of science and the arts had contributed to corrupt or improve morals," he was on the point of taking sides in favor of the arts and sciences. When, however, Diderot pointed out the advantages of taking the more striking position, he at once accepted it, and the "Discourse upon Science and Arts" was the result. This of course was the key to all of his later writings. It is fair to say that his whole system took its rise in a chance remark, and was the outcome of a desire to attract attention rather than of any high moral purpose.

As a writer and thinker this mental defect had its points of advantage to him. Any thought that occurred to him was given full expression. He need feel no restraint from facts. A half truth was as good as a whole truth, provided only it be picturesque. He could work out a line of thought as in a dream and publish it without feeling the paralysis of the demand for consistency. When the next thought presented itself he need not reject it because it was incompatible with his last publication. As a psychasthenic he was probably incapable of passing upon the truth or consistency of his ideas. He could believe each in turn with all the fervor of his nature, and work it out to its full logical conclusion with no regard for anything else.

Rousseau is one of the best instances in support of the theory that genius is allied to insanity. He illustrates at once the strength and the weakness of the insane type of genius. He was full of new and original ideas that found room to germinate uncontrolled and unchecked by any rational considerations of mutual compatibility and truth. Friend and foe find in these characteristics the basis of adoration and criticism. In the riot of opinion each reader can find what appeals to him. He suits all, as does the phrenologist with his patter. Each can select what seems true to him and overlook or forget the rest. Thus Kant could find in his writings the seeds of his categorical imperative, as truly as the leaders of the Reign of Terror could find support for their excesses. Pestalozzi drew from him justification for discarding all that was in books, while the literary leaders of the enlightenment were inspired to

return to classical models. While the man who goes to him in a sympathetic spirit finds in him a seer with inspiration for every different mood, the critic who looks to see what his teaching really is finds that there is on every point not one opinion, but several, that there is nowhere consistency, and when comparison is made between precept and act he finds every reason to suspect insincerity. The opposing theories are reconciled, however, when we recognize that we are dealing with an unstable nervous system, that Rousseau was not competent to coordinate and test his theories, nor to exert full control over his acts. His theories are dreams, his acts are the acts of a somnambulist. They should not be judged by the ordinary standards.

Enough of the psychology of Rousseau: our real question is, what did Rousseau contribute to psychology? This is somewhat difficult to answer. His specific contributions are practically *nil*. The psychology that he uses in his writings is varied. Passages in the Émile are evidently taken almost verbatim from Condillac, other passages he evidently owes to Descartes, while still others show the influence of Locke. In no place does he develop any important views of his own or even harmonize those that he borrowed. He had no followers in psychology. One can point to no one who was distinctively a psychologist that owes much to Rousseau. His strongest influence has been very recent and very indirect. Through his educational teachings that instruction should be based upon a knowledge of the child, he has perhaps had some small part in stimulating the studies of childhood that have been made in the past few decades.

Rousseau's greatest contribution to psychology is probably the raw material that he provided in his Confessions. No one else has attempted to lay bare the innermost secrets of his life in the same degree. Were it to be worked over carefully there is undoubtedly much of great value. Even this however suffers from two drawbacks. It is written for the most part so long after the events that it is probably inaccurate. It is rather Rousseau's theory of what his life should have been when viewed from near its close than a real account of the life itself. The second difficulty is the pathological character of the material. It has furnished much material or at least many illustrations to the psycho-pathologist, but the student of the normal mind must take all the statements with caution.

If Rousseau's influence upon psychology was negligible, his influence upon philosophy was of great importance. His greatest contribution to that discipline was through his effect upon Kant. Little as there seems to be in common between the stern German rationalist and the unbalanced French enthusiast, there is much to indicate that Rousseau affected Kant's general ideas in no inconsiderable degree. Of common knowledge is the story that Kant gave up his daily walk to read

the Emile, and thereby caused perturbation in the minds of the burghers accustomed to set their watches by the habits of the philosopher. Kant himself bears witness to the fact that Rousseau and Hume were the two thinkers who had most profoundly influenced him, and Rousseau's portrait was the one ornament of his study. The personal admiration of Kant for Rousseau was undoubtedly profound.

When we turn to discover specific evidence of the presence of Rousseau's theories in Kant's writings, the task is not so simple. Kant was in no sense a disciple of Rousseau. Authorities differ widely as to how much and what shall be assigned to Rousseau, from the general plan of the three critiques to a few specific elements in the ethics. There seems to be good evidence that Kant became interested in the problems of man soon after he read Rousseau, or, as another puts it, that he took from Rousseau his tendency to a democratic as opposed to an aristocratic basis for morals. Wenley suggests that much of Kant's theology may be found in "The Confessions of Faith of a Savoyard Vicar" and the corresponding fourth book of Émile. Dieterich puts the emphasis upon the similarities in the ethical systems, and would trace the categorical imperative to Rousseau's doctrine of conscience and his general tendency to find the seat of authority in man's own nature. Superficially regarded, there seems little similarity between anything in Rousseau and the categorical imperative, but careful historical examination makes a fair case for their kinship. Thus we find several points at which the half-mad and altogether irresponsible Frenchman supplied grist for the mill of the most staid of modern German philosophers.

The influence of Rousseau upon Fichte and Schelling, both directly and indirectly through Kant, was also considerable. We can not go into details in the time at our disposal, but it is not too much to say that it is possible to trace the influence of Rousseau's spirit and some of his specific theories through a large part of modern philosophy.

It is in education, however, that Rousseau's theories have been most important. In later educational writers, we can find not merely possible traces of his way of thinking, but we can find his theories restated over and over, often without credit, and always thinly veiled. Most of the current educational theories can be matched in Rousseau. The doctrine of interest, that a child should learn only as he becomes interested, is Rousseau's. We find fully developed in him the culture-epoch theory and the doctrine of discipline by natural consequences usually credited to Spencer. The reaction from mere book knowledge was also made much of. Émile, it will be recalled, was not to know how to read at twelve and then was to acquire knowledge at first hand as much as possible. It is to Rousseau that we owe our vocational units. Rousseau's doctrines contributed largely to the development of later systems. Pestalozzi and Froebel drew inspiration directly from him, and Herbart

owes much to him. Herbert Spencer also shows his influence indirectly, although he had not read Émile when he wrote his essay on education. For good or for ill, then, the popular educational doctrines of the day can be traced to Rousseau.

In brief, Rousseau had an important place in both philosophy and education. It would be interesting to ask how many of Rousseau's doctrines were his own and how many were merely borrowed and worked over. Many of his theories can be traced to earlier men, to Montaigne, to Rabelais, to Montesquieu. His educational theories were largely modified from Locke and Condillac, and the influence of the classics was great in all departments. Much more was common thought and common talk among his associates—what might be called the spirit of the age. What there is left that is original is difficult to say. Certainly, nowhere else among the writers of the age have these ideas been brought together and put with such emotional fervor and literary skill. Whoever may have originated the ideas, Rousseau gets credit for them because of his skill in exposition. Certainly no one better than he represents all the contradictory tendencies of his age.

Still another question presents itself in connection with a man like Rousseau. Does he deserve any credit for his ideas? They present themselves in striking profusion in a highly unstable nervous system, ideas, good, bad and indifferent, queerly assembled and altogether out of relation to each other and to the acts of the man himself. It may even be questioned whether Rousseau was able to distinguish between the true and false, the worthy and the unworthy. Each was given expression with no reference to anything else or to its value. There was apparently no definite purpose in their utterance, aside from pleasing the reader or satisfying the artistic sense of the writer, there was even no responsibility for them. It might be asked in retort how far any one deserves credit for his ideas, and how many men have been able accurately to guage the value of their contributions. Rousseau furnishes an enigma in this respect, but all questions of credit in this fundamental sense are enigmatical. Certain it is that an occasional unstable nervous system of this sort is likely to be a spot where ideas of value germinate and makes for progress in the world of thought. Whether Rousseau is to be regarded as a credit or debit on the world's books depends upon the point of view. The relatives of the victims of the Reign of Terror would give one answer; you would get another if you asked the men of all ages who have enjoyed the brilliant literary work of Rousseau or the increasing democracy that followed the French Revolution, assuming, which is an open question, that Rousseau was really responsible for the economic change.

SMOKING AND FOOTBALL MEN

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WITHIN recent years several investigations have been made concerning the effect of smoking on college students, but in the opinion of the present writer the bases upon which conclusions were founded were often of such a nature that the results were more or less indefinite and unreliable. It has been very difficult to segregate the effects of smoking from other factors, particularly those of physical fitness and of social environment. In most, if not all, of these investigations, all classes of students have been included, ranging from the typical scholarship men to those who are in attendance, largely because of participation in athletic sports. Students of different ambitions, of different social classes, of different methods of living have been considered alike in one great group in such a way that the results were often susceptible of various interpretations.

In order satisfactorily to arrive at a definite conclusion concerning the effect of smoking an investigation should include men alike in physical and mental aptitude, except as modified by the use of tobacco. In general the men should be equal in physical fitness; it is manifestly undesirable to compare recluse scholarship men with those who are in attendance largely because of athletics. If such a heterogeneous group of men were examined with respect to scholastic standing the athlete would unjustly suffer, while if the same group were examined with respect to athletic attainment the injustice would fall upon the scholarship man, as it is quite generally recognized that the percentage of smokers is higher among athletes than among scholarship men. So far as possible the men should be alike in social tendency, as activity in social functions tends toward smoking and low scholarship. The socially inclined student, therefore, is likely to be a smoker and to belong to the low-scholarship group, but whether his low scholarship is due to his smoking or to his social tendency is difficult, if not impossible, to decide. In the main, therefore, the students under investigation should be either scholarship men or athletic men; they should be participating in the same kind and amount of athletic sport; they should be carrying the same amount of scholastic work; they should be taking part in the same kind of social activities.

While it is not claimed that all of these disturbing factors have

been eliminated in the investigation about to be described, yet it is confidently believed that several of them have been largely avoided. It is difficult if not impossible to obtain a large group of men conforming in detail to the requirements above outlined, yet the closer such a group is approached the more reliable will be the results.

It occurred to the writer some three years ago that the football squad forms a very nearly homogeneous group. In the first place, the men are all athletes approaching physical perfection, a fact which tends to unify their mental attitude as well as their physical. Of recent years the eligibility rules have made it well-nigh impossible for transients and low scholarship men to "make the team," the regulations requiring the men to carry full courses not only during the year of participation, but also during the previous year. Socially the football men are much more alike than any group promiscuously gathered from the student body.

It is quite apparent that reliable conclusions can not be drawn from the records of a single football squad. Two years ago a few of the athletic directors in institutions in the inter-mountain states were asked to submit data relative to their football men, of course stating whether they were smokers or non-smokers. The results were very interesting and suggestive, but the number of men concerned was still rather small.

At the beginning of the present school year (1911–12) a much larger number of institutions were asked to assist in the investigation by submitting data. The following facts are based upon information received from coaches and athletic directors of fourteen American colleges and universities. The writer is fully aware of the fact that the varying conditions of the schools may introduce errors, yet they have carefully been guarded against and largely eliminated in the final summaries.

The blank forms sent out to the various athletic directors provided for the following data: age, weight, ordinary anthropometric measurements; ability on the team, whether fair, good or very good; scholastic standing of last year, including average scholarship mark, and number of conditions or failures; the number of smokers and non-smokers who attempted to "make place" on first team together with other more or less important features. The students were also to be designated as "smokers" or "non-smokers." The following foot-note appeared on each blank: "By 'smoker' is meant one who habitually smokes when not in training and not an individual who indulges at very infrequent intervals." It was thus desired that only habitual smokers be included in the list, as it is quite generally agreed that the infrequent use of tobacco is not seriously injurious.

It will not be possible to include a constant number of institutions or men in each of the various items following, as the blanks which were returned were only partially filled in; some of the institutions supplied

one series of data and some another. In the item of "try outs" six institutions reported on 210 men; in the item of "smokers or non-smokers" fourteen institutions reported on 248 men; in the item of "weight" fourteen institutions reported on 237 men; six institutions reported 108 men with respect to "lung capacity"; while fourteen institutions reported on 182 men in the item of "average scholarship mark." In each of the items following the number of men involved will be designated and also the number of institutions from which they are reported.

As just stated, six institutions furnished data relating to the "try outs." A total of 210 men contested for positions on the first teams; of this number 93 were smokers and 117 were non-smokers. Of those who were successful 31 were smokers and 77 were non-smokers. The following tabulation will make this matter clear.

Try Outs

	No. Competing	No. Successful	Per Cent. Successful
Smokers	93	31	33.3
Non-smokers	117	77	65.8

Six institutions reporting.

It will be observed that only half as many smokers were successful as non-smokers. At first thought this point may appear to be at variance with the findings of Dr. Meylan at Columbia University. Under the title "The Effects of Smoking on College Students," published in this magazine for August, 1910, Dr. Meylan makes the statement "that 41 per cent. of the smokers and only 34 per cent. of the non-smokers achieved success in varsity athletics." This statement of course tells nothing unless the exact number of smokers and non-smokers who actually tried for places in the "varsity athletics" be given. It may be that only a very small percentage of the non-smokers contested for positions and that practically all who did so were successful, while on the other hand that a much larger percentage of the smokers made the effort and a comparatively few were successful. In such a case the actual number of successful smokers might be larger than that of the non-smokers, and at the same time the percentage of the successful smoking contestants might be very much smaller than that of the non-smoking contestants. Consider the following case. Suppose an institution in which there are 400 men, 200 smokers and 200 non-smokers. Suppose that 150 of the smokers contest for positions and that 33.3 per cent. (50 men) are successful. Suppose further that only 50 of the non-smokers contest for positions and that 66.6 per cent. (33 men) are successful. In this case 25 per cent. of the total number of smokers

and only 16.6 per cent. of the non-smokers obtained places on the varsity teams. It is clear from the above that the concluding sentence means nothing unless the number of smokers and of non-smokers contesting is given.

The conclusion that smokers stand but little chance with non-smokers in obtaining places on football squads is not only shown by the total of the six institutions, but is similarly shown in each of the six. It should be observed here that the introduction of data from a single institution departing radically from the general trend of all others would influence very largely the average of the total. In such a case the average would be wholly unreliable. But in the case at hand where not only the total of the six institutions point in a given direction, but also each of the six, the average very closely approximates the truth.

The following table shows the inferiority of the smokers in each of the six institutions reporting:

	Number Competing for Places	Number Successful	Per Cent. Succesful
Institution A.			
Smokers	11	2	18.2
Non-smokers	19	11	57.9
Institution B.			
Smokers	10	4	40
Non-smokers	25	17	68
Institution C.			
Smokers	28	7	25
Non-smokers	17	14	82
Institution D.			
Smokers	28	11	39.3
Non-smokers	15	10	66.6
Institution E.			
Smokers	10	7	70
Non-smokers	15	12	80
*Institution F.**			
Smokers	6	0	0
Non-smokers	26	15	57.7

The following table gives the names of the institutions reporting and the number of smokers and non-smokers in each. Very incomplete data were submitted by three other institutions, two of which appended notes to the effect that the information was not wholly reliable. In the third institution the football squad contained no smokers. It may be well to state that the University of Utah is not included in any of the computations, as the team contained no smokers and, further, none of the men who tried for positions were smokers.

* It will be noted that no smokers obtained places on this team. In consequence of this the data from this institution are not used elsewhere in this investigation.

Institution	Smokers	Non-smokers	Total
Amherst College	9	9	18
Drake University	2	9	11
Haverford College	4	17	21
Michigan Agricultural College	3	14	17
Northwestern College	12	5	17
Tulane University	7	14	21
U. S. Naval Academy	7	5	12
University of Colorado	5	7	12
University of Kansas	10	9	19
University of Montana	12	7	19
University of Pennsylvania	12	12	24
University of Tennessee	11	10	21
Western Maryland College	7	12	19
Yanktown College	8	9	17
	109	139	248

Of the total number 44 per cent. are smokers and 56 per cent. are non-smokers. Of 213 students examined by Dr. Meylan at Columbia University 52 per cent. were smokers and 48 per cent. were non-smokers.

From the following tables it will be observed that the two classes of men are of practically the same age and weight.

	No. of Men	Combined Age	Average Age
Smokers	103	2,164 years	21.01 years
Non-smokers	134	2,821 years	21.04 years

Fourteen institutions reporting.

	No. of Men	Combined Weight	Average Weight
Smokers	103	16,645 lbs.	161.5 lbs.
Non-smokers	134	21,579 lbs.	161.0 lbs.

Fourteen institutions reporting.

While the differences in age and in weight are very slight, it should be noted that they both are in favor of the smoker. This point will be considered later.

The following table shows the relation between smoking and lung capacity.

	No. of Men	Average Weight	Average Age	Average Lung Capacity
Smokers	47	162.9 lbs.	21.06 years	286.3 cubic inches
Non-smokers	61	159.6 lbs.	20.88 years	308.9 cubic inches
Difference		3.3 lbs.	.18 year	22.6 cubic inches

Six institutions reporting.

It will be observed that smokers of the same age as non-smokers and 3.3 pounds heavier have a lung capacity of 22.6 cubic inches (7.3 per cent.) smaller. Inasmuch as the smokers are heavier than the non-

smokers by 3.3 pounds, their lung capacity should, from the standpoint of averages, be correspondingly greater. The following computations are based upon the weight and lung capacity of the non-smoker:

Non-smoker's lung capacity at 159.6 pounds is 308.9 cubic inches.
Smoker's lung capacity at 162.9 pounds is 286.3 cubic inches.
Smoker's lung capacity at 162.9 pounds should be 315.3 cubic inches.
Smoker's loss in lung capacity is 29.6 cubic inches, or 9.4 per cent.

In the item of lung capacity, it appears that the effects of smoking are almost completely segregated from those of other factors. The habit of smoking here stands strongly indicted. The evidence becomes little less than proof conclusive when it is noted in the following table that the smokers show a decided loss of lung capacity in each of the six institutions reporting.

	Average Weight Lbs.		Average Lung Capacity Cu. In.	Loss in Lung Capacity Cu. In.
Institution A.				
Non-smokers	161.8		289.1	
Smokers	167.4		284.3	
Smokers at	167.4	should have	299.1	14.8
Institution B.				
Non-smokers	161.3		287	
Smokers	166.8		291	
Smokers at	166.8	should have	296.8	5.8
Institution C.				
Non-smokers	159.7		357	
Smokers	156		336.6	
Smokers at	156	should have	348.9	12.3
Institution D.				
Non-smokers	170.2		333.8	
Smokers	175.3		313.0	
Smokers at	175.3	should have	343.8	30.8
Institution E.				
Non-smokers	149.3		296.7	
Smokers	152.5		264.3	
Smokers at	152.5	should have	303.0	38.7
Institution F.				
Non-smokers	157.7		278	
Smokers	158.7		268.1	
Smokers at	158.7	should have	279.8	11.7

The athletic directors of the various institutions were asked to divide their men into the classes, fair, good, and very good. This classification was to be based upon the ability of the men as all round football players. The following table shows the distribution of the men according to the rating of their coaches:

	No of Men	Fair	Good	Very Good
Non-smokers	139	68	50	21
Smokers	109	49	39	21
109 non-smokers would furnish ...		53.3	39.2	16.5
Smokers' excess		—4.3	0.2	4.5

From these data it appears that smokers make the better football players. In interpreting the results, however, several points should be kept in mind. In the case of the "very good" men only forty-two individuals are involved, a number rather small from which to draw reliable conclusions. A single institution reporting four or five "very good" smokers or non-smokers and none of the other group (as several institutions have done) is quite sufficient to swing the totals one way or the other. And again, while the totals from the fourteen institutions seem to favor the smokers, this is by no means uniform when the institutions are singly considered.

Even if the above data were perfectly reliable there is still another vital point to be kept in mind. In the item of "try outs" only half as many smokers were successful as non-smokers. In other words, only the very best smokers were chosen, while with the very best non-smokers a group of second-grade non-smokers was included. At the beginning of the football season when the selections were made the first and second grade non-smokers combined were equal to the first grade smokers.

Furthermore, it is a well known fact that of two men, a smoker and a non-smoker, of equal ability at the time of beginning training, the smoker will develop into a better man than the non-smoker. This is the case because the non-smoker before training is very much more nearly at his best than is the smoker. As soon, therefore, as the smoker begins training (and consequently stops using tobacco) he has a much better chance for improvement than the non-smoker, who has not been kept back by the use of tobacco. If smoking does not in any way injure one's ability on the football field, the smokers and the non-smokers should supply an equal percentage of the "very best" men.

Now, when it is borne in mind that in the "try outs" only one half as many of the smokers are chosen as non-smokers, it follows as a simple mathematical deduction that the smoking football men should supply twice as many "very good" men as the non-smokers, a position which, if the above tabulated data were wholly reliable, they come far from reaching. It will be noted, therefore, that the apparent superiority of the smokers is in reality an inferiority.

In this connection reference may profitably be made to the item of weight given in a previous table, in which it will be observed that the smokers are one half pound heavier than the non-smokers. At first thought this point may appear to be in conflict with the findings of Dr.

Seaver at Yale University,[2] where it was shown that the non-smokers were three pounds heavier than the smokers. The excess weight of the smokers is readily accounted for when it is remembered that in the "try outs" only one third of the smokers were successful, against two thirds of the non-smokers. In football, where the factor of weight plays an important part, it is quite apparent that the larger men are more likely to be selected than the smaller ones. If, however, in the "try outs" an equal percentage of the smokers and non-smokers were chosen the results would in all probability not be out of harmony with those of Dr. Seaver.

In the following the scholastic standing is shown.

	No. of Men	Total Mark	Average Mark
Smokers	81	6,034	74.5
Non-smokers	101	8,021	79.4

Twelve institutions reporting.

It will be observed that the smokers average 4.9 per cent. below the non-smokers. This average alone, however, is not wholly reliable, as the standards of marking in the various schools are by no means uniform—an individual in one institution might be ranked at 75 per cent., while in another institution this same student might be ranked at 90. From the following table, however, it will be observed that the smoker is inferior in *each of the twelve* institutions reporting, a fact, of course, which strongly corroborates the above averages.

Institution	Smoker	Non-smoker	Institution	Smoker	Non-smoker
A	65.2	69.8	G	74.0	75.0
B	64.7	74.6	H	75.2	79.4
C	78.8	81.1	I	81.6	88.4
D	75.8	77.6	J	78.5	81.3
E	84.6	84.8	K	74.0	84.6
F	69.6	71.3	L	77.3	77.6

In each of the twelve institutions reporting scholastic standing the highest and the lowest marks were tabulated for the smokers and non-smokers. The results follow:

	No. of Men	Highest Marks	Lowest Mark
Smokers	81	4	12
Non-smokers	101	11	6

Based on equal numbers of men the results would be as follows:

	Highest Marks	Lowest Marks
101 non-smokers furnish	11	6
101 smokers would furnish	5	15

[1] See *Arena*, for February, 1897.

Smokers would accordingly furnish 71 per cent. of the lowest marks, and the non-smokers only 29 per cent. The smokers would furnish 31 per cent. of the highest marks, and the non-smokers 69 per cent.

The combined conditions and failures of the two classes of men are shown in the following table:

	No. of Men	Total Conditions and Failures	Average
Smokers	82	70	.853
Non-smokers	98	43	.439

The smokers furnish twice as many conditions and failures as do the non-smokers.

The following suggestive points are brought out in this investigation:

1. Only half as many smokers as non-smokers are successful in the "try outs" for football squads.

2. In the case of able bodied men smoking is associated with loss in lung capacity amounting to practically ten per cent.

3. Smoking is invariably associated with low scholarship.

THE MINISTER'S SON

BY THE REV. CLARENCE EDWARD MACARTNEY, M.A.
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A FEW months ago, Woodrow Wilson, governor of New Jersey, stood in the little bedroom of the Presbyterian manse at Caldwell. The reason for his pilgrimage to that village and to that particular house was the fact that there Grover Cleveland, the twenty-second and twenty-fourth president of the United States, was born, March 18, 1837. Woodrow Wilson, himself the son of a Presbyterian minister, at Staunton, Va., paid a visit to the Presbyterian manse at Caldwell, out of which came a famous son. The one, now gathered to his fathers, was an oracle of the democracy, and the other is a possible democratic successor to Grover Cleveland at the White House.

The meeting of their paths at Caldwell is suggestive. Both were sons of the manse. It brings up the old question about the character of ministers' sons. Are they all sons of Belial? Are they all base fellows like the sons of Eli and Samuel? Are there none among them who do not belong to the order of Hophni and Phineas?

Charles Lamb wrote a number of essays on popular fallacies. Among the fallacies which he exposed are the following: "That a bully is always a coward"; "that you must love me and love my dog"; "that we should rise with the lark and lie down with the lamb"; "that ill-gotten gains never prosper," and "that enough is as good as a feast." We could wish that he had added one more—that ministers' sons are generally scoundrels. A long time ago Thomas Fuller wrote:

> There goeth forth a common report, no less uncharitable than untrue, as if clergymen's sons were generally unfortunate like the sons of Eli, dissolute in their lives and doleful in their deaths.

He goes on to make due allowance for "Benjamins" among the sons of ministers, that is, sons of their old age, and hence, "cockered" and humored by their ancient sires. But his conclusion is that "clergymen's children have not been more unfortunate, but more observed than the children of the parents of other professions." This last observation, coupled with a possible desire to disparage the ministry, is the sole basis for a gross fallacy, as contrary to reason as it is contrary to fact. We can all think of ministers' sons who were scallawags, no credit to a minister or to any other man. But if the general moral and intellectual standard of ministers' sons is not high, then all principles of heredity, education and environment are overthrown. Adam begat a son in his own likeness, and most ministers do the same.

The clerical family has ever been one of the chief glories of protestantism. We have no thought of opening an old discussion concerning the differing opinions of two great branches of the Christian church. It may be that the voluntary celibate may rise to a higher plane of sacrifice and devotion than the minister with a family. There have been eminent protestants who have renounced the right of marriage. Among them we find such names as Archbishop Leighton, Samuel Hopkins, William Muhlenberg, author of "I would not live alway," and the historian Neander. Suffice it to say that the reformers can not have been unmindful of the example of the patriarchs, priests and prophets of the Old Testament and the apostles of the New Testament. Peter was married, at least he had a mother-in-law, and Paul claimed the right to do as Peter had done. With this ancient precedent and sanction the reformers can not have been much troubled in conscience when they departed from the rule of one man, Hildebrand, and took to themselves wives. Luther must have had more serious reasons for renouncing the state of celibacy than those which he himself gives, viz., to please his father, tease the Pope and vex the devil. At all events, his home life was bright and happy, an earnest and a type of the clerical family life which he did so much to found. His letters to his children are models of what a father's letters to his children ought to be. Calvin was perhaps more discreet in his marriage than Luther. He may have been thinking of the sneer of Erasmus.

Some speak of the Lutheran cause as a tragedy, but to me it appears rather as a comedy, for it always ends in a wedding.

When Calvin married a demure widow of Strassburg, he could still make his boast that he had not assailed Rome as the Greeks assailed Troy, for the sake of a woman. That these early reformers succeeded in harmonizing the life of the priesthood with the life of the family has been for the glory of the church and the untold enrichment of civilization.

The minister's home is usually a home of intelligence and refinement without that ease and luxury which sap the foundations of character. His home is an answer to a wise man's prayer, "Give me neither riches nor poverty." He never gets riches, sometimes he gets poverty, but more often the lines fall unto him in the pleasant places which lie between those two extremes. However limited, the library of the minister's son will have those few books which have been the inevitable companions of genius and attainment—Plutarch's Lives, Pilgrim's Progress, Æsop's Fables, and the Bible. The son of the minister lives in an atmosphere of moral earnestness, intellectual activity and sacrifice and service for that which is highest. If any home ought to send forth a goodly line of stalwart sons it is the home of the minister.

Oliver Goldsmith, himself a minister's son, opens the "Vicar of Wakefield" with these words:

I was ever of opinion that the honest man who married, and brought up a large family, did more service than he who continued single and only talked of population; from this motive I had scarcely taken orders a year before I chose my wife as she did her wedding gown, not for a fine glossy face, but for such qualities as would wear well.

With such serious purpose and intent the founders of clerical households have exalted religion and adorned society. Goethe, when a young man, fell in love with Frederike Brion, the attractive daughter of the pastor at Sessenhiem. It was the purest and strongest love of his passionate career, and his intimate knowledge of the life of that clerical household led him to write:

A Protestant country pastor is perhaps the most beautiful topic for a modern idyl; he appears like Melchizedek, as priest and king in one person. He is usually associated by occupation and outward condition with the most innocent conceivable estate on earth, that of the farmer; he is father, master of his house, and thoroughly identified with his congregation. On this pure, beautiful, earthly foundation rests his higher vocation: to introduce men into life, to care for their spiritual education, to bless, to instruct, to strengthen, to comfort them in all the epochs of life, and, if the comfort for the present is not sufficient, to cheer them with the assured hope of a more happy future.

"The one idyl of modern life" Coleridge termed the ministerial family life, and Wordsworth thought it worthy of praise in his "Ecclesiastical Sonnets," where he sings,

A genial hearth, a hospitable board,
And a refined rusticity, belong
To the neat mansion, where, his flock among,
The learned Pastor dwells, their watchful Lord.

In 1750, Justus Möser calculated that in the two centuries after the reformation, more than ten millions of human beings in all lands owed their existence to the clerical family. In the century and a half since he made his estimate the number have very likely trebled. And what influence have these millions of ministers' children exerted upon civilization? To judge of this a brief study of eminent names in Protestant countries is most illuminating.

In the "Dictionary of National Biography," England, there are 1,270 names of eminent men who were sons of clergymen. There are 510 names of famous men who were sons of lawyers, and 350 who were sons of physicians. In this single compilation of great names in English history there are 410 more sons of ministers than sons of doctors and lawyers together. In a recent issue of "Who's Who," for America, out of nearly 12,000 names, almost 1,000 are sons of clergymen, a number out of all proportion to the whole number of ministers in the population of the country. According to that standard, there should have been not more than fifty of these famous men the sons of clergymen.

Time would fail to tell of all the notable men in all departments of human activity who were sons of ministers. We mention only a few

of these. In science, Agassiz, Fabricius, Jenner, Linnæus, Olbers, Fields, Morse, Berzelius, Euler; in history and philosophy, George John Romannes, John G. Wilkinson, Hallam, Hobbes, Froude, Sloan, Parkman, Bancroft, Schnelling, Schliermacher, Nietzsche, Müller; in art, Reynolds and Christopher Wren; in philanthropy, Clarkson and Granville Sharp, the anti-slavery agitators; in poetry, Lessing, Tennyson, Ben Jonson, Cowper, Goldsmith, Thomson, Coleridge, Addison, Young, John Keble, Matthew Arnold; among essayists, Emerson, Richter, Hazlitt; among novelists, Charles Kingsley, Henry James, and three daughters of clergymen, Jane Austen, Charlotte Brontë, and Harriet Beecher Stowe.

But most remarkable is the long list of celebrated divines who were themselves sons of ministers. Among such are these names, Swedenborg, the seer, Jonathan Edwards, Archibald Hodge, Henry Ward Beecher, Lyman Abbott, Charles Spurgeon, Increase and Cotton Mather, Matthew Henry, the famous commentator, Frederick D. Maurice, Lightfoot, John and Charles Wesley, Mansell, Dorner and Dean Stanley.

In our American history the Field family is a noble example of the influence of clerical households. The father, the Reverend David D. Field was a minister of the Congregational church. One son, David Dudley, was the eminent jurist and law reformer; another, Stephen J., was an associate justice of the Supreme Court; a third son, Henry M., was a useful clergyman and author; and the fourth son was Cyrus W., who laid the Atlantic cable.

It is probable that ministers' sons have exerted more influence in the United States than in any other country. Among teachers, lawyers, doctors, scientists, men of business, and in the church, there are a great host who have been the sons of the manse. Of the more notable men in our history who were sons of ministers we find in political life, Cleveland, Clay, Buchanan, Arthur, Quay, Morton, Beveridge, Hughes, and the lamented Dolliver of Iowa; among jurists, Field and Brewer; among educators, Woodrow Wilson, Faunce, James, Carroll, Lounsbury; in history and literature, Sloan, Parkman, Bancroft, Holmes, Emerson, Henry James, Lowell, Gilder, Van Dyke; in invention and science, Cyrus W. Field, Samuel F. Morse, and Agassiz; in the church, Beecher, Alexander, Hodge, Abbott, Potter, Jonathan Edwards; in philosophy, James. In the Hall of Fame fifty-one famous Americans are honored. Of these fifty-one, ten are the children of ministers: Agassiz, Beecher, Harriet Beecher Stowe, Henry Clay, Jonathan Edwards, Emerson, Lowell, Morse, Bancroft, Holmes.

The Protestant ministry is justified of her children. Like the fabled Pactolus of Syria, whose sands carried the wealth of Crœsus, the ministerial family has flowed down the valleys of our national life weighted with the golden dust of achievement and renown.

HISTORY-MAKING FORCES

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HISTORY is a science; it belongs to the family of social sciences. History is concerned with more than the mere perfunctory cataloging of incidents, with more than a string of events held together by the colorless thread of chronology. It is no longer to be considered a record of sanguinary episodes and of individual prowess or debauchery. True history presents a picture of the struggles of conflicting races, interests, sections and classes; it tells the interesting story of the struggle of the masses upward toward equality. Historical science is a study of cause and effect. In the political and social world, structures are evolved and changes take place in response to modifications in the physical and social environment, or in the industry of the people. Political institutions, wars and royal intrigues are but the visible manifestations of underlying and powerful social, economic, geographic and racial forces. History—true history—is, consequently, a study of the social physics of the past; sociology, of the present. It is, indeed, "the record not of the doings of man, but of his progress." The memoirs of the "not-great" are the most important, but usually the neglected, part of real history. Unless the study of history aids in the solution of the important social and economic problems of to-day, it remains in the lower rank of leisure-class, cultural studies—the value of which is chiefly traditional and putative. In our progressive educational institutions history is not offered merely for the sake of storing up in the mind of the youth a knowledge of the past, for its disciplinary value only, for so-called cultural purposes, or because it is considered to be the proper or conventional kind of knowledge for a college graduate to become familiarly acquainted with.

The medieval mind had no idea of causation in the physical world; only comparatively recently did the men of modern times begin to throw off medievalism in regard to social progress. According to the early metaphysical conception of history, data and investigations were of no value, or of negative value. In a similar way, the medieval authorities considered inductive physical science to be improper and immoral. However, metaphysics and superstition in regard to the evolution of political institutions are fortunately rapidly giving way to scientific hypotheses based upon exact and detailed investigation of historical data.

The proper function of real historical study is to ascertain and ex-

plain in a measure the reason for the rise and fall of specific nations, parties and principles. Before broad and reasonable generalizations can be drawn an enormous mass of exact and uncolored historical data must be gathered and digested. This material must relate not merely to political events or to the work and ideals of certain great and more or less spectacular personages who have stood in the foreground in the generations which lie forever behind the present. This data must, if it be highly valuable, tell the true story of the life, ideals, customs, industrial and social relations of the mass of the common people. Each locality, class and individual can add its quota toward the accurate knowledge of the true history of a given nation.

In the past our historians have often been guilty of presenting a false picture of the history of a nation. Their conclusions have often been very much prejudiced and distorted. In part this unfortunate situation was the direct and inevitable result of a lack of minute and local historical data. In part, it was due to a false idea of patriotism which led the writers to over-emphasize the good qualities of certain historical personages and to accentuate the moral weakness of others; it caused the historians to find altruistic and broad-minded ideals where in reality egoistic and particularistic ambitions were uppermost. Not only were false ideals presented, but the glorification of the past inevitably made the student and reader pessimistic in regard to the present and the future. The past was seen constantly surrounded by an unreal halo. The imaginary good old days and the more or less mythical heroic heros of the past when placed in comparison with the somber, but actual, present checked the enthusiasm of many a young idealist. With this contrast in view the present seemed hopelessly degenerate; corruption, graft and political chicanery were believed to be of recent origin, whereas in reality these evils are as old as history. It is often difficult for the student to realize that the men of former generations were not supermen, but men liable to be influenced by prejudice, partisan bias and ignoble motives. American history has suffered greatly in the past because of superficial and prejudiced interpretation of facts, and because of the lack of definite and accurate data.

The forces concerned in history-making are a multitude in comparison with those more simple and tangible forces which operate in the laboratory of the physicist or the factory of the manufacturer. Each nation and each age has its own peculiar problems, balance of social forces and rate of change. The complexity and the magnitude of the forces involved insure the existence of social inertia. The first law of social change is that social formation and deformation take place gradually. Revolutions, signifying great and abrupt changes in national economic or social life, are more apparent than real. The revolution is a mere surface manifestation. Deep-seated changes never occur in this

way. Forms of government may be radically changed, but the alignment of classes, subordination, legal traditions, religious, ethical and social ideals still remain inevitably to nullify or to modify the results of the newly-made structure of government.

The French Revolution is the classic example of a political revolution. Yet the French Revolution led directly to Napoleon. Absolutism was not immediately abolished by the downfall of Louis XVI. For the stable despotism of the Bourbon ruler was substituted the unstable and constantly changing absolutism of the assembly and the directory and finally of Napoleon. The Reign of Terror was simply the use of direct and primitive methods of maintaining control over the masses and of overriding opposition. Kings, supported by hereditary prestige and crystallized legal and constitutional forms, did not need to use, except occasionally, the crude method of wholesale legal assassination in order to maintain order and subordination. But the newly organized government with its devoted band of untried dictators, unsupported by the trappings and the legal and constitutional mummery, were quickly driven by necessity to the use of the guillotine. An immediate change from absolutism to republicanism was a governmental impossibility. The French Revolution was in effect the spectacular part of a gradual process of social change which greatly modified political conditions in France. A similar conclusion may be drawn from the English revolutions of 1642 and 1688, or from the American revolution.

Nevertheless, governmental structures may retard or modify the course of social change. A written constitution is a crystallization of an outgrown balance of social forces; but it may disturb the balance of forces in the present era. It adds to the strength of one element, and places obstacles in the path of another. Environmental conditions, the mixture of races and nationalities, social customs, tradition, religious ideals and inherited ethical principles may do likewise.

The course of historical events in America furnishes a very interesting and instructive study in social physics. The alignment of social forces in American history presents certain well-marked peculiarities. (1) The importance of the frontier element in our history is perhaps unparalleled. The history of the United States down to recent times has been warped and twisted by the presence of an ever-moving frontier line which has visibly reflected its ideals and views of government back into the legislation and the social composition of the entire country. (2) The absence of a royal or noble class based upon hereditary privilege must not be overlooked. (3) Negro slavery produced dangerous sectional antagonism which led directly to the civil war. The presence of the negro furnishes a very different problem for the American legislator and social scientist of to-day. (4) The continued influx of a large and diverse immigrant class has exercised and is still exercising a

marked influence upon our political and social institutions. Here differences in customs and traditions produce effects similar to those which result from differences in color.

The tradition that woman should remain in the home, that her sphere is the restricted one of the household, is an almost insurmountable obstacle in the path of the woman-suffrage movement. This moss-covered, but orthodox, tradition greatly weakens the effect of the economic forces which are acting to place woman on an economic and political basis level with that occupied by the masculine sex; and thus it retards a development which is indigenous to an industrial community of the occidental type. Human beings are prone to argue on the basis of what has been rather than on the ground of what is. Men hold that good which is customary forgetting that good is always relative to present conditions. Past good is often present evil; and present vices, past virtues.

Laws shortening the working day for men and women, regulating dangerous employments, and permitting the activities of labor unions, are met by an appeal to personal liberty of a kind which is practically meaningless in modern industrial society. Traditional rights are often valueless when studied in the light of the present; but their potency comes from the fact that their appeal is to the emotions, not to the reason, or to class interest rather than to the general welfare or to race improvement. A highly protective tariff is carried down into a time when the primary motive for such regulation is lost, by means of the pressure of certain pecuniary interests built up in a measure by the tariff law itself.

Religious ideals are utilized frequently to retard social change. Religious imperatives and biblical phraseology are invoked to continue the traditional view as to marriage and divorce. The standard of the formalist is that of religious justification or taboo rather than of social welfare; and the particularly unfortunate element in the whole matter is that the average formalist never grasps the idea that his religious imperatives were built up in the past when economic and social conditions were very different from those of to-day. The thoroughgoing formalist is obsessed by the idea of fixity in all moral, ethical and religious ideals and requirements. He is unfortunately so insistent upon upholding a fixed and authoritative ideal of individual goodness or of individual conformity to certain doctrines or ceremonial forms that he can not see the intricacy and complexity of modern social relations and the potency of environmental reaction upon the character and ideals of individual members of society. The religious formalist is a conservative; he is prone to look askance upon the sociologist who is studying the great social cauldron as the chemist examines his test-tube or the biologist the organism under the lens of his microscope. The sociolo-

gist is judged, and rightly judged, to be an innovator and a radical; therefore he is held to be vulgar, uncultured, dangerous, an undesirable individual and probably a "heretic" (whatever that may mean). The religious worker of the future must cast off his antiquated garb and become a student of modern society. If not, his power for good will soon be a vanishing quantity.

One of the most potent conservative and reactionary influences on American progress is our federal constitution. This document was drawn in an era before the trust, the railway, the world market and a multitude of revolutionary discoveries and theories. It can be amended only with extreme difficulty; and has only been continued by stretching the meaning of words to fit new conditions. But as the interpretation of the phraseology of the constitution is given to men who were trained a generation or more ago, and who are members of a profession which is peculiarly precedent-shackled, even this crude method does not suffice to enable our legal forms to conform to the ever-changing social and economic requirements of the present.

As long as free land and a frontier were important factors in the nation, the constitution could be adequately stretched to meet new situations—the old *laissez faire,* individualistic interpretation of liberty and constitutional rights was not seriously out of step with the course of events. But when the frontier disappears, and great industry enters, our legal and constitutional edifice is subjected to serious strain. Liberty, the right of contract, the right to do business, and similar indefinite phrases must be interpreted anew in the light of a changed and complicated economic and industrial situation. Yet, our courts seem prone to decide cases relating to the relation of labor to capital in the same way that John Marshall did. It is apparently forgotten that when aggregated capital faces organized labor, the situation is very different from that which obtained when the isolated employer faced the independent worker. Legal forms have not infrequently concealed and overshadowed common sense and social welfare; the inalienable rights of men often seem to have been displaced by the sacred rights of property and privilege.

Race prejudice often acts as a force opposing economic pressure. Slavery in the south was becoming in 1860 an uneconomical system even for the slave owner; but the progress toward emancipation was blocked by the fear of the free negro and the demand of social conventionalities. The negro race is at the present time handicapped because of race prejudice which prevents its members from obtaining the same economic opportunity as their white-skinned neighbors or competitors. Yet, on the other hand, race prejudice seems frequently, if not usually, to be generated out of economic friction and antagonism, out of the opposition engendered by competition between people accustomed to widely different standards of living.

Education may be an instrument of progress or of conservatism. When emphasis is laid upon the classical or so-called cultural elements, education becomes a potent force in maintaining the *status quo*. When the emphasis is placed upon the narrowly practical—purely trade instruction of a restricted sort—the tendency is to increase the distinction between the different classes in the community. Education only becomes a potent factor in human progress when sociological and psychological principles are introduced to determine the proper treatment of each and every child. The social standard of education is progressive; the business and the cultural standards are conservative or reactionary.

Social scientists are reaching the long-delayed conclusion that happenings in the social and the political sphere are not the result of chance, and individual impulse or willing, or of direct and arbitrary interference of an infinite power. Social and political happenings, like physical and chemical actions and reactions, occur in an orderly and law-abiding manner. Events, movements, reforms, agitations, decay or growth of institutions may, in a measure, be prophesied, directed and aided or retarded. There is, or may be, a social science (or social sciences) as well as physical sciences. Social mechanics, social physics and social chemistry are real terms.

Science is gathering data for cooperative and purposive action. Industrial evolution, city planning, workingmen's insurance, tax reform and socialism are some of the lines along which the infant science of society is slowly feeling its way—like the physical sciences of a few generations ago—in the face of opposition which is often violent, noisy, hypocritical and ignorant. Science has brought order out of chaos and guesswork in the factory. Why can it not do likewise in the nation? To the social scientist rule-of-thumb methods, secrecy, waste of natural and human resources and disregard of social welfare and of race improvement are criminal. The social scientist is becoming an expert, and is acquiring the professional spirit. He is the future maker of history.

INDUSTRIALISM

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IT is unusual nowadays to write hopefully of our own times; it is so easy to point out the shortcomings of the industrial age, and so difficult clearly to see beyond the rapid changes of our times and properly to measure the huge forces now at work in society. To many critics, this is but the age of material things; poetry, faith, the hope eternal, have quite forsaken the human heart. Such critics look upon the industrial leader and the engineer as just so much wasted material that might have gone (in a better age, of course) to make a poet or an artist. I shall not attempt to explain industrialism, or to seek an inner meaning without admitting the transient evils—to do so would be to claim that great epochs of readjustment are not periods of discomfort and even disaster to many of the species.

Culture, in its many forms, developed and embraced no new types from the dawn of civilization until modern times, except those which burst forth in the past century. The forces that have brought the race to its present place—at least most of them—are readily agreed upon. First is war, then religion, then poetry and literature, then art, philosophy, commerce, music, capital, politics, society, science, industrialism. The first in this list I name in order of their force or potency. The final two—science, industrialism—I name last with prophetic intent. They are the new giants in modern civilization, and novel in this, that they are the first great forms of culture that are antagonistic to some of the ancient types which have so long dominated human destiny.

Must I justify placing war first among the forces that have given us the civilization of to-day? It is enough to illustrate it by our own century and a third of national experience. War it was that gave us independence. It was the Mexican War that confirmed us a Pacific, as well as an Atlantic, power—with all the consequences that must flow therefrom in the distant future. Again, it was civil war that knit us together as a nation, and made us strong to work out our destiny as a single people. And again it was war that entered us upon our career as a world power, a new nationalism at home, a new imperialism abroad. And lastly, it was war—trivial it is true, only a Panama revolution let loose from Washington, but, nevertheless, war—that gave us Panama and has led to one of the most far-reaching results of all time—namely, the proof that the white man can conquer the tropics. Thus is war the

mightiest, as well as the most monstrous, of the culture forms that have yet influenced the race. No language rolls the "r" sufficiently to pronounce "war" as it should be pronounced.

These old forces of civilization—war, religion, poetry—have been harmonious coworkers; only a few unpleasant incidents to record in the happy family. Whether war for religion's sake, or religion in the cause of war, or poetry in praise of war and its heroes, or poetry in the service of religion, the forces have not often pulled against each other, but, in the main, together, and the paths in the various fields have not been divergent, but convergent. Homer, Achilles, Moses, David, Cæsar, Mohamet, Charlemagne, Dante, Shakespeare are all artists upon the same canvas.

In a large sense, science and industrialism are not two forces, but a single force. Industrialism is merely science in action, or militant science. But in reality this distinction is a large one. To make industrialism from science, one must add other elements—such, for example, as ambition for power, a greed for exploitation, or a lust for money, or any combination of these. Of course industrialism could not have developed except from the soil of science.

The brief history of industrialism is interesting. I shall divide it into three periods. In the beginning the exploitation of labor was, perhaps, the dominant quality. Now the exploitation of labor was nothing new in the world, for it dates back to the time of the first slave. What I mean is that after a long period of partial emancipation in which the common man had gained a certain power of individual assertion and independent existence, industrialism came along and built up the necessary great groups of dependent industrial workers. The exploitation of labor was on a new scale and done almost consciously as in slavery. Then, as industrialism grew and science pointed out more and more what the new movement really meant, the exploitation of labor became more nearly secondary to the exploitation of nature or of natural resources. To take in private possession and hold against the people the natural wealth of a country was, perhaps, not altogether a new thing, but the machines, the processes, the transportation, the organization, the communication that science developed made the exploitation possible and abundantly worth while. Next there entered the third and greatest period, namely, the period characterized by the exploitation of the middle classes. Now here is one of the greatest discoveries of our times. The so-called middle classes are almost solely the product of industrialism. The modern industries of a country and the commerce resulting therefrom are the only forces that have anywhere built up a large middle class. The best ways to tap the savings of this class, although just discovered, are now pretty well worked out. The American industrial trust, the German syndicate, the new-style

organization of banking, the perfected method of handling insurance and trust companies, the public service corporations, the modern stock exchange, are some manifestations of the great vacuum cleaner that is sucking away at the savings of the middle classes. This, I say, is the richest field of exploitation yet discovered. Do not misunderstand me, however. I do not mean that at a meeting of the Directors of the Biggest National Bank, or of the Greatest Life Insurance Company, or of the United States Industrial Corporation, the captain of the captains of industries arises and says: "Gentlemen, the exploitation of the middle classes is the greatest discovery of modern times. What can we do to-day to further this cause? What is next to do to tap the savings of this class?" I say I do not mean that this actually happens. A thing need not be done consciously in order to be done. The result is the same whether done consciously or unconsciously. What I mean is, for example, that a monopoly price for steel against a world market considerably less is an instance of the exploitation of the middle classes. Remember, also, that formerly the savings in the cost of production by improved methods and new inventions largely accrued to the consumer. Under modern organization of industries, this saving goes very largely to increased profits and, more than that, to increased capitalization—that is, from the pockets of the middle classes. Formerly, the leaders in the industries were manufacturers, men not far removed from the middle classes themselves. Now the leaders in the industries are not manufacturers, but so-called financiers, artists in handling funds, men interested in profits, not products—and profits in large part made from the middle class by the nursing of stocks and the shuffling of securities, and not alone by the manufacturing and selling of realities. Again the control of banks and insurance companies, for the purpose of industrial adventure and for strategic ends, works primarily against the middle classes. The irony of the new force, which makes the cleaning-up process almost perfect, is seen in the unloading upon the middle classes themselves, through organized underwriting campaigns and the short circuiting of the market, of the very obligations created in the organization of the exploiting machinery.

There are many other counts that might be added to the true bill against industrialism. Many of these are often brought to our attention by those who dote on the apparent shortcomings of the present era. Industrialism has augmented and aggravated city life, and has put the moral and physical fibers of men to new tests. It has attracted the brightest intellects to leadership in its army, much to the loss of politics, and the professions and the arts. All these things are, in a way, true. But it is not the purpose of this paper to convict industrialism, but to acquit it, so I must not catalogue its apparent shortcomings. I shall now attempt to show that industrialism, moving forward on the

rails laid by science, is working for good and not for evil, and that the things commonly criticized are but transient phases of a great movement, which, in its main features, is making for the advance of the race and toward the very highest ideals.

Let me again remind you that industrialism is but another name for science in action. The pure science of the study or laboratory it is not. This same science joined to some form of worldly ambition is industrialism. Therefore, where science leads, it must follow. It is, I claim, the most dependent upon science of all purely worldly activities. These things I shall attempt to make clear as I proceed. Trace forward what science must do for us, and we shall comprehend whither industrialism is leading .

Do not forget these truths: It is science that is dominating this age, this twentieth century, and not industrialism. Science works through industrialism. Science dominates industrialism. Science corrects the evils it itself creates. Science has not only changed the forms and conditions of our physical existence, it has altered our mental life, has controlled our views and changed the basis upon which rest our fears, hopes and opinions. The old forms of culture have been so long present as factors in the life of the race, that it is hopeless to trace out their due contribution to society. Causes have slowly fused with effects, and influences, at first external, have become internal, a part of life itself. Not so with the newest type of culture. Science is now at work remaking the world, primarily a force from without. Its first great effect is spiritual rather than material. It has spread through humanity a spirit of optimism. It has made optimists of every one, especially of the common man. So much has been accomplished by science, although but vaguely comprehended, that the ordinary man deems all things possible. Science, through its many phases and effects, has become the moral sunshine of modern life. It warms and cheers and gives a joy and hope to this present life that former generations but hesitatingly attributed to a future existence.

I shall now illustrate the way in which science corrects the evils it itself creates, and show that the dangers brought in by the new culture are merely transient. Science, the father of industrialism, is the ultimate parent of that tremendous exploitation of the natural wealth of the world which in two generations has spent more of our coal, iron and many other resources than were used by all of the preceding generations. Science has created the problem of conservation. Now I read nowhere in the books of the conservationists that science is the real criminal that has caused our natural resources to be exploited. Perhaps I find it not there, because science, now the prosecutor, must forget its own crimes.

Science has not only created the problem of conservation, but it has spread abroad a spirit of optimism that makes men believe that all will

still be well when the soil is in the ocean, and iron is rust and the last lump of coal is on the hearth. It is science that has created the new faith that makes of conservation a real and a difficult problem. But if science has created the problem of conservation and has spread a faith as an obstacle to its solution, it is still true that science alone can furnish the remedy. It is but poetic justice that science and the leaders in science must now point the way and carry much of the burden. Science must now give, and it is giving, the solution of the problem it itself has created.

What is true of the problem of conservatism is true of all of the difficulties and evils brought to us by science, whether directly or through industrialism. Science brings its own remedies and removes the evils it itself creates. If it were otherwise, science would not be science.

A second influence of industrialism that is rarely credited to it is the changed view held by the prosperous classes as to their obligation to society in general. Public opinion no longer supports the man whose life brings no form of high service to his fellow men. The very fact that business and industry are organized on so large a scale soon convinces us that the personal independence of the proprietor no longer exists. Scores of new dependencies and checks hem him about. He sees that his life must be one of social purpose and not pleasure. As obscurely as this truth is often seen, and as glaringly as it is contradicted by the sporty spirit and the society itchings of the new-rich, we must hold it as one of the characteristics of our era that social purpose and not play is dignified by industrialism. Riding to hounds as a vocation no longer gives the complete social satisfaction that it once did.

Let us now turn from these, which are, after all, minor influences of industrialism, to a consideration of some of the major tendencies. Perhaps the greatest mission of science and industrialism to our era is the removal of controversy from human progress. This is indeed a great service to mankind—to narrow the field of strife, to remove obstacles, to settle great public matters by bringing to bear accurate data, adequate analysis of cause and effect, and expert judgment—so that contention, or partisanship or politics, is eliminated, and things are settled on their merits. This phase of the industrial age is fast developing. The numerous expert commissions appointed by the states and government to investigate and determine important questions upon the basis of exact knowledge is a pertinent illustration. The Wisconsin Commission is settling all matters concerning the public utilities solely after adequate investigation and skilled tests. These same matters can never again become the football of partisanship or political manipulation. Likewise the commission form of municipal government is removing from the field of politics, and local contention, questions which are really largely

matters of skill and exact science. The best kind of water supply, the proper sort of sewage disposal, the best way to handle streets, street-railways, public parks, schools, playgrounds, public health, the housing problem, etc., are no longer matters of fight or ballot in well-ordered communities. There exists always a best way and experts are selected to find and direct it. The modern civilized community is no longer a state, but a school. The body politic has become one vast, complexly organized, research institution. Governments are, in this age of industrialism, instruments for replacing darkness with light, for substituting for the indefinite and approximate, the definite and accurate. This is about all there is to the best public service. The state has become a great thinking, investigating organization, or laboratory, or research institution. There is this distinction between the school and the state: the school researches only, the state researches and acts.

The illumination of great public matters by modern scholarship is best illustrated by what is constantly occurring in the countries of western Europe. There, as every one knows, municipalities are in the hands of experts whose life work is a study, as in a laboratory, of the needs of the community and its individuals. Nothing is left to chance, and little to choice, except when the people can be trusted to choose wisely. The city and state with its utilities, sanitary inspection, land purchase, construction and sale of homes for working men, control of food, care of children, supply of milk, expert advice to mothers, the promotion of all sorts of special schools, museums, galleries, theaters, concert halls, municipal banks, pawnshops, employment bureaus, industrial insurance, old-age pensions, etc., etc., is conducting a laboratory for racial and civic betterment, and is carrying upon the broad shoulders of the state the burden that a democracy would shift to the people themselves. All new or difficult questions receive special study and an honest attempt is made to settle them in the best manner.

The doctrine of the president of the University of Wisconsin that the state university exists for and should serve all of the people of the state is but a recognition in another form of a principle which has been admitted by older civilizations for a generation or more. Whether an American state will be willing to go at present very far on this path is questionable. It is too far a step from the reign of pull and graft to the rule of knowledge. But in the end the state will accept the higher leadership, no matter how many ups and downs may intervene.

Another of the major influences of industrialism has been its destructive power over democratic government. Democracy, the dream of the eighteenth century, became the illusion of the nineteenth. Government of the people, by the people, has not only never been realized, it would probably have been undesirable, if realizable. Whatever name may be given to the modern well-ordered government, it is not democ-

racy. The duties of the state have become too complicated, too much continuity of service and scholarship is required of its experts, to permit that direct dependency upon the electors that democracy presupposes. About as well select a university faculty by popular vote, as to get together the administrative body of a great state by choice of the people. Those governments which are most democratic in form have not always been most democratic in fact. In America we have had rule by those who could profit most by ruling. Again, American democracy has been minimized by the courts of law, a new sort of autocracy but little dreamed of by the makers of our government—a form of autocracy that would long ago have proved intolerable were it not for the scholarship and patriotism of our higher courts. The popular preachers of democracy, such as Roosevelt and La Follette, contradict their own doctrine of the cure of democracy by more democracy, by many of the policies they advocate. The short ballot, the numerous commissions and many other planks of their platform have little to do with government of the people, by the people. What is left is government for the people. There is daily less and less in government that can be left to chance and less that should be left to choice. The public welfare has become complex, controlled by the intricate forms of modern organized society. Its proper guidance is a subject of skill and knowledge and special training, rather than a matter of votes.

The last of the major influences of industrialism that I shall consider is the effect upon Christianity. A startling phenomenon of the nineteenth century was the panicky alarm shown for a time by the church as science rather suddenly took its place among the older forces of civilization. The churchmen became especially agitated at Darwinism and the laying bare of the facts at the basis of the genesis of species. The good Bishop of Oxford, in his now famous attack on Darwinism at the British Association meeting of 1860, was as little prepared for the celerity with which his position would become obsolete among his own clergy as he was unready for the swiftness and completeness of Huxley's reply. For a time there was conflict and controversy. Then there followed peace. The clergy soon realized that to be priests of darkness was not to be priests at all. The church discovered that there could be no enemy in science and scholarship. Even to the present time, however, the world has not fully awakened to the fact that science is not only not an enemy, but that it is the most potent ally that Christianity has yet found. During the twenty centuries of its history Christianity has not struggled alone. War, poetry, art, music, have diligently served it. But it has required the slow treading of centuries to find that war has no place in such a list. It seems unbelievable, sometimes, that the progress of great ideas should be so incredibly slow among our race. The patience of Providence is boundless, for al-

most without exception, his great truths penetrate humanity only after many centuries. Christianity itself is no exception. In one sense, Christianity may be said to have died out a generation or two after the death of Christ, for its fundamental truth then began to vanish. When in the middle ages the church deemed itself more powerful than worldly dynasties, it had, in the essence of Christ's teachings, lost all but the semblance of the truth. Christianity was too profound a doctrine and humanity too frail a vessel.

The essential and profound truth of Christianity I take to be this: that the law of the jungle, the law of the tooth and claw, must be replaced for the human species by a higher law; that humanity can only reach its most perfect development and realize the highest ideals through the reign of unselfishness. The beginning of Christianity thus marks the transition of man from the kingdom of a lower to the kingdom of a higher being. The Golden Rule is the definition that discriminates one domain from the other. It has become the mission of the industrial age to separate out from Christianity the essential from its unessential doctrine.

That the message of Christ is opposed to some of the primitive forces of culture, such as war, for example, has been but poorly discerned. War is the most perfect embodiment of human selfishness. It is selfishness in its most concentrated and brutal form. Let us give credit to this industrial age that has laid bare these simple truths. Science has replaced war in the list of the allies of Christianity. The exploration of nature has revealed and demonstrated the inadequacy of the law of the jungle for human progress. Science has supplied us with the methods and the laws wherewith to check up human phenomena and to show wherein and to what extent the selfish elements are controlling in human activities. Science is supplying the instruments, the test tubes and the balances, not for material things alone, but for checking up our own experiences, and for applying to life itself those tests that determine the elements that control in each configuration.

If science has given us the tools, the methods, the point of view, industrialism has given us the laboratory and the fiery furnace in which to test them. The bringing of men together in great dependent groups, the subdivision of human effort, the new conditions of life, the accidents and dangers of modern industrial employment, have forced upon us problems in bulk, and not in single instances. The business world has shown how to divide up investments, risks and profits by the joint stock organization. It has drilled us in the elimination of hazards and the division among the many of the ownership and reward of the industries. This very phenomenon emphasizes by contrast and makes inevitable the consideration of the sharing of the hazards of the life of the individual by society in general. To place the burdens of the individual upon the

broad shoulders of the state is therefore but a reflex from industrialism itself. A community of interests among the prosperous classes and class hatred between the proprietary and the working classes can not permanently coexist. If the industrial trust brings peace where there was war, this peace must finally extend to humanity itself. Industrialism has eliminated the middle ground and the possibility of compromise. Peace between the giant groups is progress—warfare between the giant groups is destruction. Science cures the ills it itself creates.

There is thus brought up to our era as the essential terms of permanence, the acceptance of the fundamental message of Christianity. Unselfish cooperation, appreciation and love of our fellow travelers, is the condition of progress. The industrial age, as it develops, must become the most cultured, the most gracious, the kindliest of the eras that the human family has yet lived. Industrialism compels the rule of men by the principle of charity. It has brought us to a climax in human affairs. Society can push forward only on the basis of a revived and reconstructed Christianity. Charity, love, unselfishness, the Golden Rule—whatever you may name the law—has begun to be the necessary and sufficient condition of advance. This present era is not the old age of Christianity—it is its childhood. As the biologist might say, the Industrial Age is a period of rapid mutation. The type is changing. It is a day of hope and of optimism, such as the world has not hitherto known.

THE INHERITANCE OF FECUNDITY[1]

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A THOROUGH and searching investigation of two great biological problems is a necessary prerequisite to any substantial advance of the science of eugenics. These problems are:

1. The mode of inheritance of human characters and traits of all kinds.

2. The physiology of reproduction in man, particularly with reference to human fecundity and fertility.

The progressive decline of the birth-rate in all, or nearly all, civilized countries is an obvious and impressive fact. Equally obvious and much more disturbing is the fact that this decline is differential. Generally it is true that those racial stocks which by common agreement are of high, if not the highest value, to the state or nation, are precisely the ones where the decline in reproduction rate has been most marked.

The causes concerned in the production of these results are without question exceedingly complex and difficult, if not impossible, of complete analysis. But of one thing we may be certain; somewhere in the complex of causes is included the biological factor as one element. Fecundity and fertility are physiological characters of the organism, subject to variation and capable of being inherited, just in the same manner as structural characters. We must be in possession of definite information regarding the physiology of fecundity and fertility, before it will be possible to make safe and sure advance in the social and eugenic analysis of matters involving these factors, such as, for example, the declining birth-rate.

The basic eugenic significance of that characteristic of organisms termed fecundity furnishes sufficient justification, I hope, for bringing to the attention of this Congress certain results regarding fecundity in one of the lower animals, namely the domestic fowl. In some particulars the results are, I believe, novel. They indicate, for the first time, the precise mode by which this complex physiological character fecundity is inherited. It will be the purpose of this paper to present—necessarily very briefly and without the detailed supporting evidence—the essential results of a study of fecundity in poultry, pointing out at the end some possible eugenic bearings of the results.[2]

[1] This paper was read at the First International Eugenics Congress, held in London, July 24–30, 1912.

[2] The results set forth below were first presented at the meeting of the American Society of Naturalists at Princeton, N. J., in December, 1911. A

During the course of this investigation into the inheritance of fecundity in the domestic fowl, which has now involved thirteen generations and several thousand individuals, two definite and clear-cut results have come to light. These are:

First: that the record of egg production or fecundity of a hen is not, of itself, a criterion of any value whatsoever from which to predict the probable egg production of her female progeny. An analysis of the records of production of large numbers of birds shows beyond any possibility of doubt that, in general, there is no correlation between the egg production of individuals and either their ancestors or their progeny.

Second: that, notwithstanding the fact just mentioned, fecundity is, in some manner or other, inherited in the domestic fowl. This must clearly be so, to mention but a single reason, because it has been possible to isolate and propagate from a mixed flock "pedigree lines" or strains of birds which breed true, generation after generation, to definite degrees of fecundity. Some of these lines breed true to a high condition or degree of the character fecundity; others to a low state or degree.

Definite as these results are, they give no clue as to *how* fecundity is inherited; what the mechanism is. It is believed that now a first approximation to the solution of this problem has finally been reached. While there remain obscure points yet to be cleared up, and more data are needed definitely to decide between certain alternatives, yet the results now in hand appear to indicate quite clearly the general character of the mechanism of the inheritance of fecundity, and to show what lines further investigation of the problem may most profitably take.

At the outstart it will be well to understand clearly what is meant by the term fecundity as here used. I have used the term "fecundity" only to designate the innate potential reproductive capacity of the individual organism, as denoted by its ability to form and separate from the body mature germ cells. Fecundity in the female will depend upon the production of ova and in the male upon the production of spermatozoa.

Fecundity is obviously a character depending upon the interaction of several factors. In the first place the number of ova separated from the body by a hen or any other animal must depend, in part at least, upon an *anatomical* basis, namely the number of ova present in the ovary and available for discharge. Further there must be involved a series of physiological factors. It has been possible to prove that the mere presence of an anatomically normal reproductive system, including a normal ovary with a full complement of ova, and a normal ovi-

complete report with full presentation of the experimental data will shortly be published in the *Journal of Experimental Zoology.*

duct, is not enough to insure that a hen shall lay eggs, that is, exhibit actual as well as potential fecundity. While comparatively very rare, cases do occur in which a bird possesses a perfect ovary and perfect oviduct and is in all other respects entirely normal and healthy, yet never lays even a single egg in her life time. Such cases as these prove: first, that what we may call the anatomical factor is not alone sufficient to make potential fecundity actual; and second, that the anatomical and physiological factors are distinct, in the sense that the normal existence of one in an individual does not necessarily imply the coexistence of the other in the same individual.

Turning now to the physiological factors involved in fecundity, it would appear that there are at least two such factors or groups of factors. The first of the physiological factors involved may be designated the "normal ovulation" factor. By this is meant the complex of physiological conditions which, taken together, determine the laying of about such a number of eggs as represents the normal reproductive activity of the wild *Gallus bankiva.* It must be remembered that, for reasons which can not be gone into here, under conditions of domestication the activity of this normal ovulation factor will mean the production of considerably more eggs than under wild conditions. Egg production involves certain definite and rather severe metabolic demands, which under wild conditions will not always, or even often be met. Further, as has been especially emphasized by Herrick, egg-laying in wild birds is simply one phase of a cyclical process. If the cycle is not disturbed in any way the egg production is simply the minimum required for the perpetuation of the race. If, however, the cycle is disturbed, as, for example, by the eggs being removed from the nest as fast as they are laid, a very considerable increase in the total number of eggs produced will result.

It is a fact well known to poultrymen, and one capable of easy observation and confirmation, that different *breeds* and *strains* of poultry differ widely in their laying capacity. In saying this the writer would not be understood to affirm that a definite degree of fecundity is a fixed and *unalterable* characteristic by any particular breed. The history of breeds shows very clearly that certain breeds now notably poor in laying qualities were once particularly good. One of the best examples of this is the Polish fowl. But, in spite of this, not only do these breed and strain differences in fecundity exist, and probably always have existed, but they are *inherited.* Such inherited differences are independent of feeding or any other environmental factors. Thus a strain of Cornish Indian Games with which I have worked are poor layers, regardless of how they are fed and handled. This is merely a statement of particular fact; it does not imply that there may not exist other strains of Cornish Indian Games that are good layers.

Now in individuals which are high layers, and have this characteristic in hereditary form, there must be involved some sort of physiological factor in addition to the normal ovulation factor already discussed. An analysis of extensive statistics has shown that high fecundity represents essentially an addition of two definite seasonal, laying cycles to the basis normal reproduction cycles. These added periods of productivity are what may be called the winter cycle and the summer cycle. The winter cycle is the more important of these. It is the best measure of relative fecundity which we have and has been used as the chief unit of fecundity in these studies. It constitutes a distinct and definite entity in fecundity curves. The existence of these added fecundity cycles in high laying birds must depend upon some additional physiological factor of mechanism besides that which suffices for the normal reproductive egg production. Given the *basic* anatomical and physiological factors, the bird only lays a *large* number of eggs if an additional factor is present.

We may next consider in greater detail these factors influencing fecundity, taking first

The Anatomical Basis of Fecundity

Since, as already pointed out, egg production obviously depends in part upon the presence of ova in a normal ovary, a question which demands consideration is the following:

To what extent are observed *variations* in fecundity (*i. e.,* in the number of eggs laid) to be referred to anatomical differences? In other words, does the ovary of a high-producing hen with, for example, a winter record of from 75 to 115 eggs contain a larger number of oocytes than does the ovary of a hen which is a poor producer, laying *no* eggs in the winter period and perhaps but 10 or 15 eggs in the year?

To get light upon this question the observations to be described have been made. The object was to arrive at as accurate a relative judgment as possible regarding the number of oocytes in the ovaries of different individual birds. It is, of course, impossible practically to determine accurately the total absolute number of oocytes in the ovary. What can be done, however, is to count the number of oocytes which are visible to the unaided eye. While such results do not tell us, nor enable us to estimate with great accuracy, the total number of oocytes in the ovary, they do, nevertheless, throw interesting and useful light on the questions raised above. Some counts of this kind are shown in Table I.

From this table it is in the first place clear that the number of oocytes in the ovary of a hen is very large; much larger, I think, than has generally been supposed. While, to be sure, there are for the most part only vague statements respecting this point in the literature,

usually these statements are to the effect that the bird's ovary contains "several hundred" ova.

Table I

Showing the Number of Visible Oocytes in the Ovary of Certain Fowls

Case No.	Bird No.	Breed	Winter Production	Total Visible Oocytes
1	8,021	Barred Plymouth Rock	3	1,228
2	8,017	Barred Plymouth Rock	0	1,666
3	8,030	Barred Plymouth Rock	0	914
4	8,005	Barred Plymouth Rock	5	1,174
5	1,376	Barred Plymouth Rock	3	2,306
6	8,018	Barred Plymouth Rock	0	1,194
7	8,009	Barred Plymouth Rock	0	2,101
8	8,010	Barred Plymouth Rock	5	1,576
9	425	Barred Plymouth Rock	0	1,521
10	3,546	White Leghorn	54	2,452
11	2,067	White Leghorn	32	3,605
12	3,453	White Leghorn	0	1,701
13	3,833	White Leghorn	0	2,145
14	52	Cornish Indian Game	13	1,550
15	71	F_1 Cross	106	2,000

Not only is the absolute number of oocytes large, but it is also very much larger than the number of eggs which any hen ever lays. A record of 200 eggs in the year is a high record of fecundity for the domestic fowl, though in exceptional cases it may go even a hundred eggs higher than this. But even a 200-egg record is only a little more than a *tenth* of the average total number of *visible* oocytes in a bird's ovary, to say nothing of the probably much larger number of oocytes invisible to the unaided eye, but capable of growth and development. In other words, it is quite evident from these figures that the potential "anatomical" fecundity is very much higher than the actually realized fecundity. This is true even if we suppose the bird to be allowed to live until it dies a natural death.

An examination of the table in detail indicates that there is no very close or definite relationship between the number of visible oocytes on the ovary and the winter production of a bird. Thus No. 1,367 and No. 3,546 each have about the same number of visible oocytes, yet one has a winter production record 18 times as great as the other. Again No. 71 with the extraordinarily high winter record of 106 eggs has only a little more than one half as many visible oocytes as hen No. 2,067, whose winter production record is only 32 eggs. Again, No. 71 with its 106 record has very nearly the same oocyte count as No. 8,010 with a winter record of zero. In general it may be said that the present figures give no indication that there is any correlation between fecundity as measured by winter production, and the number of oocytes in the ovary. Of course, the present statistics are meager. More ample figures are needed (and are being collected) from which to measure the correlation between actual and "anatomical" fecundity.

The data now in hand, however, indicate clearly, it seems to me, that there must be some other factor than the anatomical one involved in the existence of different degrees of actual fecundity in the domestic fowl. It evidently is the case that when one bird has a winter record of twice what another bird has it is *not* because the first has twice as many oocytes in the ovary. On the contrary, it appears that *all* birds have an anatomical endowment entirely sufficient for a very high degree of fecundity, and in point of fact quite equal to that possessed by birds which actually accomplish a high degree of fecundity. Whether or not such high fecundity is actually realized evidently depends then upon the influence of additional factors beyond the anatomical basis. As has already been indicated in the preceding section, it is reasonable to suppose that these factors are physiological in nature.

The Mechanism of the Inheritance of Fecundity as Measured by Winter Egg Production

A study of numerous statistics shows that hens fall into three well defined classes in respect to winter production. These classes include (*a*) those birds which lay no eggs whatever in the winter period (up to March of the laying year); (*b*) those that lay but have a production during the period of something under about 30 eggs; and finally (*c*) those whose production exceeds 30 eggs in the winter period. The division point between the two latter classes is not sharply defined in every case, but it is plainly at about 30 eggs in the case of the breeds and strains used in these experiments. Since in the analysis some fixed point must be taken for this boundary, a production of 30 has been chosen for this purpose and will be used throughout. This is an arbitrary choice only in the sense that it is a convenient round number lying very near where the biological division point falls, at least in the strains of domestic fowls used in these experiments. The analysis could doubtless be carried through nearly or quite as well by taking the division point at a production of 29 or 31, but 30 is a more convenient figure.

In making the division of winter egg production into three groups it must be remembered that this is a character subject to purely somatic fluctuations and environmental influence. Allowance for these factors must be made in interpreting and classifying results.

Turning now to the symbolic analysis, we have to deal with three factors. These are:

1. An anatomical factor. This is basic. It consists in the presence of a normal ovary, the primary organ of the female sex. In the genetic analysis a separate letter need not be used for the designation of this factor, but instead it will be understood to be included in the letter denoting the presence of the female sex or its determiner. That is, F

will denote the presence of the ovary or the ♀ sex determiner. Then f will denote the absence of femaleness and the absence of an ovary. Obviously a separate letter is not needed for this "anatomical factor," since the presence of an ovary is the objective criterion of the existence of the female sex, its absence of the existence of the male sex.

2. The "first production" factor. This is the primary physiological factor which in coexistence with F makes the bird lay eggs during the winter period. Quantitatively it may be taken as determining a winter production of more than zero eggs and less than 30. The presence of this factor will be denoted by L_1.

3. The "second production" factor. This is a second physiological factor, which in coexistence with F and L_1 leads to *high* fecundity. The presence of this factor will be denoted by L_2 and its absence by the corresponding small letter. When F and L_1 are present the addition of L_2 makes a winter production of over 30 eggs. If F is present and L_1 absent the presence of L_2 leads to a winter production of under 30 eggs. Thus either L_1 or L_2 alone makes a record of 30 eggs. They are independent determiners of this degree of production. It should be pointed out, however, that in spite of their equivalence in this regard the factors L_1 and L_2 are not qualitatively the same. That is, the increased production when L_1 and L_2 are both present is not because there are present two "doses" of the same determiner. The proof of this is found in the fact that when there are two "doses" of L_1 present in a bird it does *not* make her a high producer. L_2 may be considered an excess production factor, which erects a superstructure on the foundation furnished by L_1. In the absence of L_1 it lacks the foundation from which to start, and hence only can build about as high as L_1 would alone. Of course, it will be understood that in the presence of f (absence of female sex and ovary) these physiological fecundity factors L_1 and L_2 are simply latent.

Using the letters in the manner defined above, and with the usual Mendelian method of writing gametic and zygotic formulæ, the data indicate that there exist 9 different types (in respect to fecundity) of Barred Plymouth Rock males, 6 types of Barred Plymouth Rock females, 3 types of Cornish Indian Game males, and 3 types of Cornish Indian Game females. The only point needing particular attention in reference to these formulæ is that the factor L_2, the excess production factor, behaves in inheritance as a *sex-limited* or *sex-correlated character*. It is repelled by the female determiner F. It is thus like the barred pattern factor in the Barred Plymouth Rock fowl.[3] In consequence gametes of the type FL_2 are never formed. *Any gamete which bears F does not, under any circumstance, ever carry L_2.* All females

[3] Cf. Pearl, R., and Surface, F. M., *Arch. f. Entwick. Mech.*, Bd. XXX., pp. 45–61, 1910, and *Science*, N. S., Vol. XXXII., pp. 870–874, 1910.

which carry the excess production factor L_2 are heterozygous in respect to it.

We have fecundity practically determined, then, by two physiological factors, one of which is sex-correlated in its inheritance and the other not.

TABLE II

Showing Some Results of Mating Together Barred Plymouth Rock Males and Barred Plymouth Rock Females of Different Fecundity Genotypes. Summarized Data

Matings	Distribution of Daughters in Respect to Winter Egg Production			
	Class	Over 30 Eggs	Under 30 Eggs	Zero Eggs
♂ $fL_1L_2 \cdot fl_1l_2$ × ♀ $fL_1L_2 \cdot Fl_1l_2$ (high producer).	Observed	21	30	8
	Expected	22.1	29.5	7.4
Average winter egg production in each class.		48.85	16.34	0
♂ $fL_1L_2 \cdot fl_1l_2$ × ♀ $fL_1L_2 \cdot FL_1l_2$ (high producer).	Observed	21.5[4]	16.5	0
	Expected	19	19	0
Average winter egg production in each class.		50.38	16.69	—
♂ $fL_1L_2 \cdot fl_1l_2$ × ♀ ♀ of all types taken together.	Observed	51.5	62.5	11
	Expected	51.45	62.5	11.05
Average winter egg production in each class.		47.94	15.34	0
♂ $fl_1L_2 \cdot fl_1L_2$ × ♀ $fL_1L_2 \cdot Fl_1l_2$ (high producer).	Observed	92.5	103.5	7
	Expected	101.5	101.5	0
Average winter egg production in each class.		54.19	15.52	0
♂ $fl_1L_2 \cdot fl_1L_2$ × ♀ $fL_1L_2 \cdot FL_1l_2$ (high producer).	Observed	111	6	0
	Expected	117	0	0
Average winter egg production in each class.		56.47	20.33	—
♂ $fl_1L_2 \cdot fl_1L_2$ × ♀ $fL_1l_2 \cdot Fl_1l_2$ (low producer).	Observed	29	23	2
	Expected	27	27	0
Average winter production in each class.		47.93	15.30	0
♂ $fl_1L_2 \cdot fl_1L_2$ × ♀ ♀ of all types taken together.	Observed	243	149	10
	Expected	255.5	146.5	0
Average winter egg production in each class.		53.67	15.37	0
♂ $fL_1L_2 \cdot fl_1L_2$ × ♀ $fL_1L_2 \cdot Fl_1l_2$ (high producer).	Observed	20	6	3
	Expected	21.75	7.25	0
Average winter production in each class.		56.90	24.17	0
♂ $fL_1L_2 \cdot fL_1l_2$ × ♀ ♀ of all types taken together.	Observed	19	16	0
	Expected	17.5	17.5	0
Average winter egg production in each class.		55.47	18.3	—
♂ $fl_1L_2 \cdot fl_1l_2$ × ♀ ♀ of all types taken together.	Observed	8.5	15.5	5
	Expected	10.25	14.5	4.25
Average winter egg production in each class.		60.50	12.26	0

The accordance between observed fact and theoretical expectation on this interpretation of the results is shown in the following tables

[4] The records of ½ refer to birds whose winter production record was exactly 30 eggs. Each one of the few birds of this sort is divided between the "Over 30" and the "Under 30" classes.

which give the results of a portion of the actual experiments. As the experiments were rather extensive, it is not possible here to present anything like the complete material. Only representative matings are here given. Table II. gives the results of some of the B. P. R. × B. P. R. matings in detail, in order to show, not only the accordance between observation and theory, but also the distinctness of the classes of fecundity segregated (shown by the *average* winter production in each segregated class).

From the data set forth in the above table there can be no doubt as to the fact of the Mendelian segregation of fecundity, nor as to the entire distinctness of the things segregated.

In order to give a general survey of the results, and to demonstrate the reality of segregation over the wide range of material included in the experiments, the summary Table III is presented.

Table III

Showing the Observed and Expected Distribution in Respect of Fecundity of the Adult Female Offspring from all Matings in each of the Classes Tested in the Experiments

Matings	Winter Production of Daughters			
	Class	Over 30	Under 30	Zero
All Barred Plymouth Rock × Barred Plymouth Rock.	Observed	365.5	259.5	31
	Expected	381.45	257.25	17.30
All Cornish Indian Game × Indian Game.	Observed	2	23	15
	Expected	0	25	15
All F_1 (B.P.R. × C.I.G. and reciprocal cross).	Observed	36	79	8
	Expected	26.5	86.75	9.75
All F_2 (F_1 × F_1, and F_1 × parent forms in all possible combinations).	Observed	57.5	98.5	23
	Expected	68.60	95.00	15.40

Considering the nature of the material and the character dealt with the agreement shown between observation and hypothesis is certainly as close as could reasonably be expected. Such discrepancies as are shown in the above table are fully discussed and their probable physiological explanations set forth in detail in the complete account of these experiments.

The detailed data given in the complete paper, of which the above discussion and tables *give merely a very incomplete abstract,* appear definitely to establish the following points:

1. That fecundity in the domestic fowl is inherited strictly in accordance with Mendelian principles.

2. That observed individual variations in fecundity here depend upon two separately inherited physiological factors, L_1 and L_2.

3. That *high* fecundity is manifested only when both of these factors are present together in the same individual.

4. That either of these factors when present alone whether in homo-

zygous or heterozygous form causes about the same degree of *low* fecundity to be manifested.

5. That one of these factors, namely L_2, is sex-limited or sex-correlated in its inheritance, in such way that in gametogenesis any gamete which bears the female sex determinant F does not bear L_2.

6. That there is a definite and clear-cut segregation of high fecundity from low fecundity, in the manner set forth above.

These conclusions are fully and independently substantiated by long-continued breeding experiments involving the breeding together of (1) Barred Plymouth Rock males and females (a breed of generally high fecundity), (2) Cornish Indian Game males and females (a breed of generally low fecundity, (3) the F_1 and F_2 offspring from reciprocal crosses of Barred Plymouth Rocks and Cornish Indian Games and all possible matings *inter se* and with the parent forms of the cross-bred F_1 and F_2 offspring.

While these results may have no direct eugenic bearing, they do, I believe, have an important indirect connection with eugenic problems. In the first place, these results furnish a novel conception of the mode of inheritance of fecundity. They show that this highly variable physiological character is inherited in accord with simple Mendelian principles. They further show that simple selection of highly fecund females alone is not sufficient to ensure high fecundity in the race.

From the eugenic standpoint they suggest, though of course they do not prove, that possibly some part of the observed decline in human fecundity in highly civilized races may be due to the dropping out or loss of one or more of the genes upon which high fecundity depends, this loss being coincident with the complete cessation of the natural selection of highly fecund types.

Finally, these results on fecundity in fowls not only emphasize the importance of analytical studies to determine the precise mode of inheritance of human fecundity, but they also furnish a guide and stimulus for the conduct of such studies. If, as in the actual fact, it can be shown that in one animal belonging to the same great phylum to which man himself belongs (the vertebrate) fecundity is inherited in a simple Mendelian fashion, it encourages one to hope that some time a solution of the same problem may be reached for man. It at least points the way to a mode of attacking this complex problem which gives greater promise of leading ultimately to a solution than does any method which has hitherto been applied to it.

STUFFY ROOMS[1]

By LEONARD HILL, M.B., F.R.S.

LAST year the distinguished president of this section raised us to the contemplation of the workings of the soul. I ask you to accompany me in the consideration of nothing higher than a stuffy room. Every one thinks that he suffers in an ill-ventilated room owing to some change in the chemical quality of the air, be it want of oxygen, or excess of carbon dioxide, the addition of some exhaled organic poison, or the destruction of some subtle property by passage of the air over steam-coils, or other heating or conducting apparatus. We hear of "devitalized" or "dead" air, and of "tinned" or "potted" air of the battleship. The good effects of open-air treatment, sea and mountain air, are no less generally ascribed to the chemical purity of the air. In reality the health-giving properties are those of temperature, light, movement and relative moisture of the surrounding atmosphere, and leaving on one side those gross chemical impurities which arise in mines and in some manufacturing processes, and the question of bacterial infection, the alterations in chemical composition of the air in buildings where people crowd together and suffer from the effects of ill-ventilation have nothing to do with the causation of these effects.

Satisfied with the maintenance of a specious standard of chemical purity, the public has acquiesced in the elevation of sky-scrapers and the sinking of cavernous places of business. Many have thus become cave-dwellers, confined for most of their waking and sleeping hours in windless places, artificially lit, monotonously warmed. The sun is cut off by the shadow of tall buildings and by smoke—the sun, the energizer of the world, the giver of all things which bring joy to the heart of man, the fitting object of worship of our forefathers. The ventilating and heating engineer hitherto has followed a great illusion in thinking that the main objects to be attained in our dwellings and places of business are chemical purity of the air and a uniform draughtless summer temperature.

Life is the reaction of the living substance to the ceaseless play of the environment. Biotic energy arises from the transformation of those other forms of energy—heat, light, sound, etc.—which beat upon the transformer—the living substance (B. Moore). Thus, when all

[1] Address of the president to the Physiological Section of the British Association for the Advancement of Science, Dundee, 1912.

the avenues of sense are closed, the central nervous system is no longer aroused and consciousness lapses. Laura Bridgeman, paralyzed in almost all her avenues of sense, fell asleep whenever her remaining eye was closed. The patient who lost one labyrinth by disease and, to escape unendurable vertigo, had the other removed by operation, was quite unable to guide his movements or realize his position in the dark. Rising from bed one night, he collapsed on the floor and remained there helpless till succor arrived.

A sense organ is not stimulated unless there is a change of rate in the transference of energy; and this to be effectual must occur in most cases with considerable quickness. If a weak agent is to stimulate, its application must be abrupt (Sherrington). Thus the slow changes of barometric pressure on the body surface originate no skin sensations, though such changes of pressure, if applied suddenly, are much above the threshold value for touch. A touch excited by constant mechanical pressure of slight intensity fades quickly below the threshold of sensation. Thus the almost unbearable discomfort which a child feels on putting on for the first time a "natural" wool vest fades away, and is no longer noticed with continual wear. Thomas à Becket soon must have become oblivious to his hair shirt, and even to its harbingers. It is not the wind which God tempers to the shorn lamb, but the skin of the lamb to the wind. The inflow of sensations keeps us active and alive and all the organs working in their appointed functions. The cutaneous sensations are of the highest importance. The salt and sand of wind-driven sea air particularly act on the skin and through it braces the whole body. The changing play of wind, of light, cold and warmth stimulate the activity and health of mind and body. Monotony of sedentary occupation and of an overwarm still atmosphere endured for long working hours destroys vigor and happiness and brings about the atrophy of disuse. We hear a great deal of the degeneration of the race brought about by city life, but observation shows us that a drayman, navvy or policeman can live in London, or other big city, strong and vigorous, and no less so than in the country. The brain-worker, too, can keep himself perfectly fit if his hours of sedentary employment are not too long and he balances these by open-air exercise. The horses stabled, worked and fed in London are as fine as any in the world; they do not live in windless rooms heated by radiators.

The hardy men of the north were evolved to stand the vagaries of climate—cold and warmth—a starved or full belly have been their changing lot. The full belly and the warm sun have expanded them in lazy comfort; the cold and the starvation have braced them to action. Modern civilization has withdrawn many of us from the struggle with the rigors of nature; we seek for and mostly obtain the

comfort of a full belly and expand all the time in the warm atmosphere afforded us by clothes, wind-protected dwellings and artificial heat—particularly so in the winter, when the health of the business man deteriorates. Cold is not comfortable, neither is hunger, therefore we are led to ascribe many of our ills to exposure to cold, and seek to make ourselves strong by what is termed good living. I maintain that the bracing effect of cold is of supreme importance to health and happiness, that we become soft and flabby and less resistant to the attacks of infecting bacteria in the winter not because of the cold but because of our excessive precautions to preserve ourselves from cold; that the prime cause of "cold" or "chill" is not really exposure to cold but to the over-heated and confined air of rooms, factories and meeting places. Seven hundred and eleven survivors were saved from the *Titanic* after hours of exposure to cold. Many were insufficiently clad and others wet to the skin. Only one died after reaching the *Carpathia,* and he three hours after being picked up. Those who died perished from actual cooling of the body. Exposure to cold did not cause in the survivors the diseases commonly attributed to cold.

Conditions of city and factory life diminish the physical and nervous energy, and reduce many from the vigorous health and perfectness of bodily functions which a wild animal possesses to a more secure, but poorer and far less happy, form of existence. The ill chosen diet, the monotony and sedentary nature of daily work, the windless uniformity of atmosphere, above all, the neglect of vigorous muscular exercise in the open air and exposure to the winds and light of heaven—all these, together with the difficulties in the way of living a normal sexual life, go to make the pale, undeveloped, neurotic and joyless citizen. Nurture in unnatural surroundings, not nature's birth-mark, molds the criminal and the wastrel. The environment of childhood and youth is at fault rather than the stock; the children who are taken away and trained to be sailors, those sent to agricultural pursuits in the colonies, those who become soldiers, may develop a physique and bodily health and vigor in striking contrast to their brothers who become clerks, shop assistants and compositors.

Too much stress can not be put on the importance of muscular exercise in regard to health, beauty and happiness. Each muscle fills with blood as it relaxes, and expels this blood on past the venous valves during contraction. Each muscle together with the venous valves forms a pump to the circulatory system. It is the function of the heart to deliver the blood to the capillaries, and the function of the muscles—visceral, respiratory and skeletal—to bring it back to the heart. The circulation is contrived for a restless mobile animal; every vessel is arranged so that muscular movement furthers the flow of blood.

The pressure of the blood in the veins and arteries under the influence of gravity varies with every change of posture. The respiratory pump, too, has a profound influence on the circulation. Active exercise, such as is taken in a game of football, entails endless changes of posture, varying compressive actions—one with another struggling in the rough and tumble of the game—forcible contractions and relaxations of the muscles, and a vastly increased pulmonary ventilation; at the same time the heart's action is accelerated and augmented and the arterial supply controlled by the vaso-motor system. The influence of gravity, which tends to cause the fluids of the body to sink into the lower parts, is counteracted; the liver is rhythmically squeezed like a sponge by the powerful respiratory movements, which not only pump the blood through the abdominal viscera, but thoroughly massage these organs, and kneading these with the omentum clean the peritoneal cavity and prevent constipation. At the same time the surplus food metabolic products, such as sugar and fat, stored in the liver, are consumed in the production of energy, and the organs swept with a rapid stream of blood containing other products of muscular metabolism which are necessary to the inter-relation of chemical action. The output of energy is increased very greatly; a resting man may expend two thousand calories per diem; one bicycling hard for most of the day expended eight thousand calories, of which only four thousand was covered by the food eaten.

Such figures show how fat is taken off from the body by exercise, for the other four thousand calories comes from the consumption of surplus food products stored in the tissues. While resting a man breathes some 7 liters of air, and uses 300 c.c. of oxygen per minute, against 140 liters and 3,000 c.c. while doing very hard labor. The call of the muscles for oxygen through such waste products as lactic acid impels the formation of red corpuscles and hemoglobin. The products of muscular metabolism in other ways not yet fully defined modify the metabolism of the whole body.

Exposure to cold, cold baths and cold winds has a like effect, accelerating the heart and increasing the heat production, the activity of the muscles, the output of energy, the pulmonary ventilation and intake of oxygen and food. In contrast with the soft pot-bellied, overfed city man the hard, wiry fisherman trained to endurance has no superfluity of fat or tissue fluid. His blood volume has a high relative value in proportion to the mass of his body. His superficial veins are confined between a taut skin and muscles, hard as in a race-horse trained to perfection. Thus the adequacy of the cutaneous circulation and loss of heat by radiation rather than by sweating is assured. His fat is of a higher melting-point, hardened by exposure to cold. In him less blood is derived to other parts such as adipose tissue, skin

and viscera. He uses up the oxygen in the arterial blood more completely and with greater efficiency; for the output of each unit of energy his heart has to circulate much less blood (Kreogh); his blood is sent in full volume by the well-balanced activity of his vasomotor system to the moving parts. Owing to the perfect coordination of his muscles, trained to the work, and the efficient action of his skin and cutaneous circulation—the radiator of the body—he performs the work with far greater economy and less fatigue. The untrained man may obtain 12 per cent. of his energy output as work, against 30 per cent. or perhaps even 50 per cent. obtained by the trained athlete. Hence the failure and risk suffered by the city man who rushes straight from his office to climb the Alps. On the other hand, the energetic man of business or brain worker is kept by his work in a state of nervous tension. He considers alternative lines of action, but scarcely moves. He may be intensely excited, but the natural muscular response does not follow. His heart is accelerated and his blood pressure raised, but neither muscular movements and accompanying changes of posture, nor the respiratory pump materially aid the circulation. The activity of his brain demands a rapid flow of blood, and his heart has to do the circulatory work, as he sits still or stands at his desk, against the influence of gravity. Hence a high blood pressure is maintained for long periods at a time by vaso-constriction of the arteries in the lower parts of the body and increased action of the heart; hence, perhaps, arise those degenerative changes in the circulatory system which affect some men tireless in their mental activity. We know that the bench-worker, who stands on one leg for long hours a day, may suffer from degeneration and varicosity of the veins in that leg. Long continued high arterial pressure, with systolic and diastolic pressures approximately the same, entails a stretched arterial wall, and this must impede the circulation in the vaso vasorum, the flow of tissue lymph in, and nutrition of, the wall. Since his sedentary occupation reduces the metabolism and heat production of his body very greatly, the business man requires a warmer atmosphere to work in. If the atmosphere is too warm it reduces his metabolism and pulmonary ventilation still further; thus he works in a vicious circle. Exhausting work causes the consumption of certain active principles, for example, adrenalin, and the reparation of those must be from the food. To acquire certain of the rarer principles expended in the manifestation of nervous energy more food may have to be eaten by the sedentary worker than can be digested and metabolized. His digestive organs lack the kneading and massage, the rapid circulation and oxidation of foodstuffs which is given by muscular exercise. Hence arise the digestive and metabolic ailments so common to brain workers.

Mr. Robert Milne informs me that of the thousands of children which have passed through Barnardo's Homes—there are 9,000 in the homes at any one time—not one after entering the institution and passing under its regimen and the care of his father, Dr. Milne, has developed appendicitis. Daily exercise and play, adequate rest, a regular simple diet have ensured their immunity from this infection. It pays to keep a horse healthy and efficient; it no less pays to keep men healthy. I recently investigated the case of clerks employed in a great place of business, whose working hours are from 9 to 6 on three days, and 7 to 9 on the other three days of each week, and, working such overtime, they make £1 to £2 a week; these clerks worked in a confined space—forty to fifty of them in 8,200 cubic feet, lit with thirty electric lamps, cramped for room, and overheated in warm summer days. It is not with the chemical purity of the air of such an office that fault is to be found, for fans and large openings ensured this sufficiently. These clerks suffered from their long hours of monotonous and sedentary occupation, and from the artificial light, and the windless, overwarm and moist atmosphere. Many a girl cashier has worked from 8 to 8:30, and on Saturdays from 8 to 10, and then has had to balance her books and leave perhaps after midnight on Sunday morning. Her office is away in the background—confined, windless, artificially lit. The Shops Act has given a little relief from these hours. What, I ask, is the use of the state spending a million a year on sanatoria and tuberculin dispensaries, when those very conditions of work continue which lessen the immunity and increase the infection of the workers?

The jute industry in this town of Dundee is carried out almost wholly by female and boy labor. "The average wages for women are below 12s. in eight processes and above 12s., but under 18s., for the remaining five processes." The infant mortality has been over 170 per 1,000. The Social Union of Dundee reported in 1905 that of 885 children born to 240 working mothers no fewer than 520, or 59 per cent., died—and almost all of them were under five years of age. The life of these mothers was divided between the jute factory and the one-roomed tenement. Looking such conditions squarely in the face, I say it would be more humane for the state to legalize the exposure of every other new-born infant on the hillside rather than allow children to be slowly done to death. The conditions as given in the report contravene those rights of motherhood which the meanest wild animal can claim.

Isolation hospitals, sputum-pots and anti-spitting regulations will not stamp out tuberculosis. Such means are like shutting the door of the stable when the horse has escaped. Flügge has shown that tubercle bacilli are spread by the droplets of saliva which are carried

out as an invisible spray when we speak, sing, cough, sneeze. Sputum-pots can not control this. The saliva of cases of phthisis may teem with the bacilli. The tuberculin reaction tests carried out by Hamburger and Monti in Vienna show that 94 per cent. of all children aged eleven to fourteen have been infected with tubercle. In most the infection is a mere temporary indisposition. I believe that the conditions of exhausting work, and amusement in confined and overheated atmospheres, together with ill-regulated feeding, determine largely whether the infection, which almost none can escape, becomes serious or not. Karl Pearson suggests that the death statistics afford no proof of the utility of sanatoria or tuberculin dispensaries, for during the very years in which such treatment has been in vogue, the fall in the mortality from tuberculosis has become less relatively to the fall in general mortality. He opines that the race is gradually becoming immune to tubercle, and hence the declination in the mortality curve is becoming flattened out—that nature is paramount as the determinant of tuberculosis, not nurture. From a statistical inquiry into the incidence of tuberculosis in husband and wife and parent and child Pearson concludes that exposure to infection as in married couples is of little importance while inborn immunity or diathesis is a chief determinant. Admitting the value of his critical inquiries and the importance of diathesis, I would point out that in the last few years the rush and excitement of modern city life has increased, together with the confinement of workers to sedentary occupations in artificially lit, warm, windless atmospheres. The same conditions pertain to places of amusement, eating-houses, tube railways, etc.

Central heating, gas-radiators and other contrivances are now displacing the old open fire and chimney. This change greatly improves the economical consumption of coal and the light and cleanliness of the atmosphere. But in so far as it promotes monotonous, windless, warm atmospheres, it is wholly against the health and vigor of the nation. The open fire and wide chimney ensure ventilation, the indrawing of cold outside air, streaky air—restless currents at different temperatures, which strike the sensory nerves in the skin and prevent monotony and weariness of spirit. By the old open fires we were heated with radiant heat. The air in the rooms was drawn in cool and varied in temperature. The radiator and hot-air system give us a deadly uniformly heated air—the very conditions we find most unsupportable on a close summer's day.

In Labrador and Newfoundland, Dr. Wakefield tells me, the mortality of the fisherfolk from tuberculosis is very heavy. It is generally acknowledged to be four per 1,000 of the population per annum, against 1.52 for England and Wales. Some of the Labrador doctors

talk of seven and even eight per 1,000 in certain districts. The general death-rate is a low one. The fishermen fish off shore, work for many hours a day in the fishing season, and live with their families on shore in one-roomed shanties. These shanties are built of wood, the crannies are "stogged" with moss, and the windows nailed up, so that ventilation is very imperfect. They are heated by stoves and kept at a very high temperature, *e. g.*, 80° F. Outside in the winter the temperature may be 30 degrees below freezing. The women stay inside the shanties almost all their time, and the tuberculosis rate is somewhat higher in them. The main food is white bread, tea stewed in the pot till black, fish occasionally, a little margarine and molasses. The fish is boiled and the water thrown away. Game has become scarce in recent years; old, dark-colored flour—spoken of with disfavor—has been replaced by white flour. In consequence of this diet beri-beri has become rife to a most serious extent, and the hospitals are full of cases. Martin Flack and I have found by our feeding experiments that rats, mice and pigeons can not be maintained on white bread and water, but can live on wholemeal, or on white bread in which we incorporate an extract of the sharps and bran in sufficient amount. Recent work has shown the vital importance of certain active principles present in the outer layers of wheat, rice, etc., and in milk, meat, etc., which are destroyed by heating to 120° C. A diet of white bread or polished rice and tinned food sterilized by heat is the cause of beri-beri. The metabolism is endangered by the artificial methods of treating foods now in vogue. As to the prevalency of tuberculosis in Labrador, we have to consider the inter-marriage, the bad diet, the over-rigorous work of the fishermen, the over-heating of, and infection in the shanties. Dr. Wakefield has slept with four other travelers in a shanty with father, mother and ten children. In some there is scarce room on the floor to lie down. The shanties are heated with a stove on which pots boil all the time; water runs down the windows. The patients are ignorant, and spit everywhere, on bed, floor and walls. In the schools the heat and smell is most marked to one coming in from the outside air. In one school 50 cubic feet per child is the allowance of space. The children are eating all day long, and are kept in close hot confinement. They suffer very badly from decay of the teeth. Whole families are swept off with tuberculosis, and the child who leaves home early may escape, while the rest of a family dies. Here, then, we have people living in the wildest and least populated of lands with the purest atmosphere suffering from all those ill-results which are found in the worst city slums—tuberculosis, beri-beri and decayed teeth.

The bad diet probably impels the people to conserve their body heat and live in the over-warm, confined atmosphere, just as our

pigeons fed on white bread sit, with their feathers out, huddled together to keep each other warm.

The metabolism, circulation, respiration and expansion of the lung are all reduced. The warm, moist atmosphere lessens the evaporation from the respiratory tract, and therefore the transudation of tissue lymph and activity of the ciliated epithelium. The unexpanded parts of the lung are not swept with blood. Everything favors a lodgment of the bacilli, and lessens the defences on which immunity depends. In the mouth, too, the immune properties of the saliva are neutralized by the continual presence of food, and the temperature of the mouth is kept at a higher level, which favors bacterial growth. Lieutenant Siem informs me that recently in northern Norway there has been the same notable increase in tuberculosis. The old cottage fireplaces with wide chimneys have been replaced with American stoves. In olden days most of the heat went up the chimney, and the people were warmed by radiant heat. Now the room is heated to a uniform moist heat. The Norwegians nail up the windows and never open them during the winter. At Lofoten, the great fishing center, motor-boats have replaced the old open sailing and row boats. The cabin in the motor-boat is very confined, covered in with watertight deck, heated by the engine, crowded with a dozen workers. When in harbor the fishermen used to occupy ill-fitted shanties, through which the wind blew freely; now, to save rent, they sleep in the motor-boat cabins. Here, again, we have massive infection, and the reduction of the defensive mechanisms by the influence of the warm, moist atmosphere.

The Norwegian fishermen feed on brown bread, boiled fish, salt mutton, margarine, and drink, when in money, beer and schnapps; there is no gross deficiency in diet, as in Labrador, and beri-beri does not attack them. They return home to their villages and longshore fishing when the season is over. The one new condition which is common to the two districts is confinement in stove-heated, windless atmospheres. In old days the men were crowded together, but in open boats or in draughty shanties, and had nothing but little cooking-stoves.

The conditions of great cities tend to confine the worker in the office all day, and to the heated atmosphere of club, cinema show or music-hall in the evening. The height of houses prevents the town dweller from being blown upon by the wind, and, missing the exhilarating stimulus of the cool, moving air, he repels the dull uniformity of existence by tobacco and by alcohol, or by indulgence in food, *e. g.*, sweets, which are everywhere to his hand, and by the nervous excitement of business and amusement. He works, he eats, and is amused in warm, windless atmospheres, and suffers from a feeble circulation,

a shallow respiration, a disordered digestion and a slow rate of metabolism.

Many of the employments of modern days are detestable in their long hours of confinement and monotony. Men go up and down in a lift all day, and girls in the bloom of youth are set down in tobacco stalls in underground stations, and their health and beauty there fade while even the blow-flies are free to bask in the sun. In factories the operatives feed machines, or reproduce the same small piece of an article day after day. There is no art, or change, no pleasure in contrivance and accomplishment. The miner, the fisherman, even the sewerman, face difficulties, changing risks, and are developed as men of character and strength. Contrast the sailor with the steward on a steamer, the drayman outside with the clerk inside who checks the goods delivered at some city office, the butcher and the tailor, the seamstress and the market woman, and one sees the enormous difference which a confined occupation makes. Monotonous sedentary employment makes for unhappiness because the inherited functional needs of the human body are neglected, and education—when the outside field of interest is narrowed—intensifies the sensitivity to the bodily conditions. The sensations arising within the body—proprioceptive sensations—come to have too large a share in consciousness in comparison with exteroceptive. In place of considering the lilies how they grow or musing on the beauty and motions of the heavenly bodies, the sedentary worker in the smoke-befouled atmosphere, with the limited activity and horizon of an office and a disturbed digestion, tends to become confined to the inward consideration of his own viscera and their motions.

Many of the educated daughters of the well-to-do are no less confined at home; they are the flotsam and jetsam cast up from the tide in which all others struggle for existence—their lives are no less monotonous than the sweated seamstress or clerk. They become filled with "vapors" and some seek excitement not in the cannon's mouth, but in breaking windows, playing with fire, and hunger strikes. The dull monotony of idle social functions, shopping and amusement no less than that of sedentary work and an asexual life, impels to a simulated struggle—a theatrical performance, the parts of which are studied from the historical romances of revolution. Each man, woman and child in the world must find the wherewithal for living, food, raiment, warmth and housing, or must die or get some other to find it for him. It seems to me as if the world is conducted as if ten men were on an island—a microcosm—and five sought for the necessaries of life, hunted for food, built shelters and fires, made clothes of skins, while the other five strung necklaces of shells, made loin-cloths of butterfly wings, gambled with knuckle-bones, drew comic pictures

in the sand, or carved out of clay frightening demons, and so beguiled from the first five the larger share of their wealth. In this land of factories, while the many are confined to mean streets and wretched houses, possessing no sufficiency of baths and clean clothing, and are ill-fed, they work all day long, not to fashion for themselves better houses and clothing, but to make those unnecessaries such as "the fluff" of women's apparel and a thousand trifles which relieve the monotony of the idle and bemuse their own minds.

The discovery of radium and its disintegration as a source of energy has enabled the physicist to extend Lord Kelvin's estimate of the world's age from some thirty to a thousand million years. Arthur Keith does not hesitate to give a million of these years to man's evolution. Karl Pearson speaks of hundreds of thousands of years. The form of the human skull, the brain capacity of man, his skill as evidenced by stone implements and cave drawings of animals in action, was the same tens of thousands of years ago as now. For ages primitive man lived as a wild animal in tropical climes, discovered how to make fire, clothe himself in skins, build shelters, and so enable himself to wander over the temperate and arctic zones. Finally, in the last few score of years, he has made houses draughtless with glass windows, fitted them with stoves and radiators and every kind of device to protect himself from cold, while he occupies himself in the sedentary pursuits and amusements of a city life. How much better, to those who know the boundless horizon of life, to be a frontiers-man and enjoy the struggle, with body hardened, perfectly fit, attuned to nature, than to be a cashier condemned to the occupation of a sunless, windless pay-box. The city child, however, nurtured and educated in confinement, knows not the largeness and wonders of nature, is used to the streets with their ceaseless movement and romantic play of artificial light after dark, and does not need the commiseration of the country mouse any more than the beetle who lives in the dark and animated burrows of his heap. But while outdoor work disciplines the body of the countryman into health, the townman needs the conscious attention and acquired educated control of his life to give him any full measure of health and happiness.

Experimental evidence is strongly in favor of my argument that the chemical purity of the air is of no importance. Analyses show that the oxygen in the worst-ventilated school-room, chapel or theater is never lessened by more than 1 per cent. of an atmosphere; the ventilation through chink and cranny, chimney, door and window, and the porous brick wall, suffices to prevent a greater diminution. So long as there is present a partial pressure of oxygen sufficient to change the hemoglobin of the venous blood into oxyhemoglobin there can arise no lack of oxygen.

At sea-level the pressure of oxygen in the pulmonary alveolar air is about 100 mm. Hg. Exposed to only half this pressure the hemoglobin is more than 80 per cent. saturated with oxygen.

In noted health resorts of the Swiss mountains the barometer stands at such a height that the concentration of oxygen is far less than in the more ventilated room. On the high plateau of the Andes there are great cities: Potosi with a hundred thousand inhabitants is at 4,165 meters, and the partial pressure of oxygen there is about 13 per cent. of an atmosphere in place of 71 per cent. at sea-level; railways and mines have been worked up to altitudes of 14,000 to 15,000 feet. At Potosi girls dance half the night, and toreadors display their skill in the ring. On the slopes of the Himalayas shepherds take their flocks to altitudes of 18,000 feet. No disturbance is felt by the inhabitants or those who reach these great altitudes slowly and by easy stages. The only disability to a normal man is diminished power for severe exertion, but a greater risk arises from want of oxygen to cases of heart disease, pneumonia, and in chloroform anesthesia at these high altitudes. The newcomer who is carried by the railway in a few hours to the top of Pikes Peak or the Andes may suffer severely from mountain sickness, especially on exertion, and the cause of this is want of oxygen. Acclimatization is brought about in a few days' time. The pulmonary ventilation increases, the bronchial tubes dilate, the circulation becomes more rapid. The increased pulmonary ventilation lowers the partial pressure of carbon dioxide in the blood and pulmonary air, and this contributes to the maintenance of an adequate partial pressure of oxygen. Haldane and Douglas say that the percentage of red corpuscles and total quantity of the hemoglobin increases, and maintain that the oxygen is actively secreted by the lung into the blood, but the C method by which their determinations have been made has not met with unqualified acceptance. If waste products, which arise from oxygen want, alter the combining power of hemoglobin, this alteration may not persist in shed blood; for these products may disappear when the blood is exposed to air. Owing to the combining power of hemoglobin the respiratory exchange and metabolism of an animal within wide limits is independent of the partial pressure of oxygen. On the other hand, the process of combustion is dependent not on the pressure but on the percentage of oxygen. Thus the aeroplanist may become seized with altitude sickness from oxygen want, while his gas engine continues to carry him to loftier heights.

The partial pressure of oxygen in a mine at a depth of 3,000 feet is considerably higher than at sea-level, and if the percentage is reduced to 17, while the firing of fire-damp and coal dust is impossible, there need be in the alveolar air of the lungs no lower pressure of oxygen than at sea-level. Thus the simplest method of preventing

explosions in coal mines is that proposed by J. Harger, viz., to ventilate them with air containing 17 per cent. of oxygen.[2] There is little doubt that all the great mine-explosions have been caused by the enforcement of a high degree of chemical purity of the air. In the old days when ventilation was bad there were no great dust explosions. Mr. W. H. Chambers, general manager of the Cadeby mine, where the recent disastrous explosion occurred, with the authority of his great and long practical experience of fiery mines, told me that the spontaneous combustion of coal and the danger of explosion can be wholly met by adequate diminution in ventilation. The fires can be choked out while the miners can still breathe and work. The Coal Mines Regulation Act enforces that a place shall not be in a fit state for working or passing therein, if the air contains either less than 19 per cent. of oxygen, or more than 1¼ per cent. of carbon dioxide. A mine liable to spontaneous combustion of coal may be exempted from this regulation by order of the Secretary of State.

The regulations impel the provision of such a ventilation current that the percentage of oxygen is sufficient for the spread of dust explosions along the intake airways, with the disastrous results so frequently recorded. If the mine were ventilated with air containing 17 per cent. of oxygen in sufficient volume to keep the miners cool and fresh, not only would explosions be prevented, but the mines could be safely worked and illuminated with electricity, and miners' nystagmus prevented, for this is due to the dim light of the safety lamp. The problem possibly may be solved by purifying and cooling the return air, and mixing and circulating this with a sufficiency of fresh air.

Owing to the fact that the percentage of CO_2 is the usual test of ventilation and that only a very few parts per 10,000 in excess of fresh air are permitted by the English Factory Acts, it is generally supposed that CO_2 is a poison and that any considerable excess has a deleterious effect on the human body. No supposition could be further from the truth.

The percentage of CO_2 in the worst ventilated room does not rise above 0.5 per cent., or at the outside 1 per cent. It is impossible that any excess of CO_2 should enter into our bodies when we breathe such air, for whatever the percentage of CO_2 in the atmosphere may be, that in the pulmonary air is kept constant at about 5 to 6 per cent. of an atmosphere—by the action of the respiratory center. It is the concentration of CO_2 which rules the respiratory center, and to such purpose as to keep the concentration both in the lungs and in the blood uniform (Haldane); the only result from breathing air containing 0.5 to 1 per cent. of CO_2 is an inappreciable increase in the ventila-

[2] *Trans. Inst. of Mining Engineers*, 1912.

tion of the lungs. The very same thing happens when we take gentle exercise and produce more CO_2 in our bodies.

At each breath we rebreathe into our lungs the air in the nose and large air-tubes (the dead-space air), and about one third of the air which is breathed in by a man at rest in dead-space air. Thus, no man breathes in pure outside air into his lungs. When a child goes to sleep with its head partly buried under the bed-clothes, and in a cradle confined by curtains, he rebreathes the expired air to a still greater extent, and so with all animals that snuggle together for warmth's sake. Not only the new-born babe sleeping against its mother's breast, but pigs in a sty, young rabbits, rats and mice clustered together in their nests, young chicks under the brooding hen, all alike breathe a far higher percentage than that allowed by the Factory Acts. To rebreathe one's own breath is a natural and inevitable performance, and to breathe some of the air exhaled by another is the common lot of men who, like animals, have to crowd together and husband their heat in fighting the inclemency of the weather.

In the Albion Brewery we analyzed on three different days the air of the room where the CO_2 generated in the vats is compressed and bottled as liquid carbonic acid. We found from 0.14 to 0.93 per cent. of CO_2 in the atmosphere of that room. The men who were filling the cylinders and turning the taps on and off to allow escape of air must often breathe more than this. The men engaged in this occupation worked twelve-hour shifts, having their meals in the room. Some had followed the same employment for eighteen years, and without detriment to their health. It is only when the higher concentrations of CO_2 are breathed, such as 3 to 4 per cent. of an atmosphere, that the respiration is increased, so that it is noticeable to the resting individual; but percentages over 1 per cent. diminish the power to do muscular work, for the excess of CO_2 produced by the work adds its effect to that of the excess in the air, and the difficulty of coordinating the breathing to the work in hand is increased.

Haldane and Priestley found that with a pressure of 2 per cent. of an atmosphere of CO_2 in the inspired air the pulmonary ventilation of a man at rest was increased 50 per cent., with 3 per cent. about 100 per cent., with 4 per cent. about 200 per cent., with 5 per cent. about 300 per cent. and with 6 per cent. about 500 per cent. With the last, panting is severe, while with 3 per cent. it is unnoticed until muscular work is done, when the panting is increased 100 per cent. more than usual. With more than 6 per cent. the distress is very great, and headache, flushing and sweating occur.

Divers who work in diving dress and men who work in compressed air caissons constantly do heavy and continuous labor in concentrations of CO_2 higher than 1 per cent. of an atmosphere, and so long as the

CO_2 is kept below 2 to 3 per cent. they are capable of carrying out efficient work. In the case of workers in compressed air it is important to bear in mind that the effect of the CO_2 on the breathing depends on the partial pressure and not on the percentage of this gas in the air breathed.

By a series of observations made on rats confined in cages fitted with small, ill-ventilated sleeping chambers, we have found that the temperature and humidity of the air—not the percentage of carbon dioxide or oxygen—determines whether the animals stay inside the sleeping room or come outside. When the air is cold, they like to stay inside, even when the carbon dioxide rises to 4 to 5 per cent. of an atmosphere. When the sleeping chamber is made too hot and moist they come outside.

The sanitarian says it is necessary to keep the CO_2 below 0.01 per cent., so that the organic poisons may not collect to a harmful extent. The evil smell of crowded rooms is accepted as unequivocal evidence of the existence of such. He pays much attention to this and little or none to the heat and moisture of the air. The smell arises from the secretions of the skin, soiled clothes, etc. The smell is only sensed by and excites disgust in one who comes to it from the outside air. He who is inside and helps to make the "fugg" is both wholly unaware of and unaffected by it. Flügge points out, with justice, that while we naturally avoid any smell that excites disgust and puts us off our appetite, yet the offensive quality of the smell does not prove its poisonous nature. For the smell of the trade or food of one man may be horrible and loathsome to another not used to such.

The sight of a slaughterer and the smell of dead meat may be loathly to the sensitive poet, but the slaughterer is none the less healthy. The clang and jar of an engineer's workshop may be unendurable to a highly strung artist or author, but the artificers miss the stoppage of the noisy clatter. The stench of glue-works, fried-fish shops, soap and bone-manure works, middens, sewers, become as nothing to those engaged in such, and the lives of the workers are in no wise shortened by the stench they endure. The nose ceases to respond to the uniformity of the impulse, and the stench clearly does not betoken in any of these cases the existence of a chemical organic poison. On descending into a sewer, after the first ten minutes the nose ceases to smell the stench; the air therein is usually found to be far freer from bacteria than the air in a school-room or tenement.

If we turn to foodstuffs we recognize that the smell of alcohol and of Stilton or Camembert cheese is horrible to a child, while the smell of putrid fish—the meal of the Siberian native—excites no less disgust in an epicure, who welcomes the cheese. Among the hardiest and healthiest of men are the North Sea fishermen, who sleep in the cabins

of trawlers reeking with fish and oil, and for the sake of warmth shut themselves up until the lamp may go out from want of oxygen. The stench of such surrounding may effectually put the sensitive, untrained brain worker off his appetite, but the robust health of the fisherman proves that this effect is nervous in origin, and not due to a chemical organic poison in the air.

Ventilation can not get rid of the source of a smell, while it may easily distribute the evil smell through a house. As Pettenkofer says, if there is a dung-heap in a room, it must be removed. It is no good trying to blow away the smell.

Flügge and his school bring convincing evidence to show that a stuffy atmosphere is stuffy owing to heat stagnation, and that the smell has nothing to do with the origin of the discomfort felt by those who endure it. The inhabitants of reeking hovels in the country do not suffer from chronic ill-health, unless want of nourishment, open-air exercise, or sleep come into play. Town workers who take no exercise in the fresh air are pale, anemic, listless. Sheltered by houses they are far less exposed to winds, and live day and night in a warm, confined atmosphere.

The widespread belief in the presence of organic poisons in the expired air is mainly based on the statements of Brown Sequard and D'Arsenval, statements wholly unsubstantiated by the most trustworthy workers in Europe and America. These statements have done very great mischief to the cause of hygiene, for they led ventilating engineers and the public to seek after chemical purity, and neglect the attainment of adequate coolness and movement of the air. It was stated that the condensation water obtained from expired air is poisonous when injected into animals. The evidence on which this statement is based is not only not worthy of credence but is absurd, *e. g.*, condensation water has been injected into a mouse in a quantity equivalent to injecting 5 kilograms into a man weighing 60 kilograms. No proper controls were carried out. It is recognized now that any distilled water contaminated by bacterial products may have a toxic effect. Flack and I have for fourteen weeks kept guinea-pigs and rats confined together in a box and poorly ventilated, so that they breathed air containing 0.5 to 1.0 per cent. of CO_2. The guinea-pigs proved wholly free from anaphylactic shock on injecting rat's serum. Therefore they were not sensitized by breathing the exhaled breath of the rats for many weeks, and we are certain that no foreign protein substance is absorbed in this way. It has been proved by others, and by us, that animals so confined do well so long as they are well fed and their cages kept clean, light, cool and dry. It is wholly untrue that they are poisoned by breathing each other's breath. The only danger arises from droplet contagion in cases of infective disease.

To study the relative effect of the temperature and chemical purity of the atmosphere I constructed a small experimental chamber of wood fitted with large glass observation windows and rendered air-tight.

On one side of the chamber were fixed two small electric heaters, and a tin containing water was placed on these in order to saturate the air with water vapor. On another side of the chamber was placed a large radiator through which cold water could be circulated when required, so as to cool the chamber. In the roof were fixed three electric fans, one big and two small, by means of which the air of the chamber could be stirred. The chamber held approximately 3 cm. of air. In one class of experiments we shut within the chamber seven or eight students for about half an hour, and observed the effect of the confined atmosphere upon them. We kept them until the CO_2 reached 3 to 4 per cent., and the oxygen had fallen to 17 to 16 per cent. The wet-bulb temperature rose meanwhile to about 80° to 85° F., and the dry bulb a degree or two higher. The students went in chatting and laughing, but by-and-by, as the temperature rose, they ceased to talk and their faces became flushed and moist. To relieve the monotony of the experiment we have watched them trying to light a cigarette, and, puzzled by their matches going out, borrowing others, only in vain. They had not sensed the diminution of oxygen, which fell below 17 per cent. Their breathing was deepened by the high percentage of CO_2, but no headache occurred in any of them from the short exposure. Their discomfort was relieved to an astonishing extent by putting on the electric fans placed in the roof. Whilst the air was kept stirred the students were not affected by the oppressive atmosphere. They begged for the fans to be put on when they were cut off. The same old stale air containing 3 to 4 per cent. CO_2 and 16 to 17 per cent. O_2 was whirled, but the movement of the air gave relief, because the air was 80° to 85° F. (wet bulb), while the air enmeshed in their clothes in contact with their skin was 98° to 99° F., wet bulb. If we outside breathed through a tube the air in the chamber we felt none of the discomfort which was being experienced by those shut up inside. Similarly, if one of those in the chamber breathed through a tube the pure air outside he was not relieved.

R. A. Rowlands and H. B. Walker carried out a large number of observations in the chamber, each acting as subject in turn. They recorded the effect on the respiratory ventilation and on the pulse rate both when resting and when working. The work consisted in pulling a 20-kilogram weight about 1 meter high by means of a pulley and rope. In some of the experiments the exhaled carbonic acid was absorbed, and in others carbonic acid was put into the chamber. The subjects inside could not tell when the gas was introduced, not even if the percentage were suddenly raised by 2. The introduction of this

amount of the gas made no sensible difference to them, but increased their pulmonary ventilation. In every one of the experiments they suffered from the heat, and the putting on of the fans gave great relief, and in particular diminished the pulse rate during and after the working periods. The relief became much greater when cold water was circulated through the radiator and the temperature of the chamber lowered 10° F. The subjects wore only a vest, pants and shoes in most of these experiments. When they wore their ordinary clothing the effect on the frequency of the pulse was more marked and the discomfort from heat and moisture much greater.

I have made observations on men dressed in the Fleuss rescue apparatus for use in mines, and exposed in a chamber to 120° F. dry bulb and 95° F. wet bulb. The skin temperature rises to the rectal temperature and the pulse is greatly accelerated—*e. g.*, to 150—and there arises danger of heat stroke. The conditions are greatly relieved by interposing on the inspiratory tube of the apparatus a cooler filled with carbonic-acid snow. The cool inspired air lowers the frequency of the heart and makes it possible for the men to do some work at 95° F. wet bulb, and to endure this temperature for two hours.

The observations made by Pembrey and Collis on the weaving-mill operatives at Darwen show that the skin of the face may be 4° to 13° F. higher in the mill when the wet bulb is 71° F. than at home when the wet-bulb temperature is about 55° F. The tendency of the warm, humid atmosphere of the mill is to establish a more uniform temperature of the body as a whole (surface and deep temperatures) and to throw a tax upon the power of accommodation as indicated by the rapid pulse and low blood-pressure.

The mill-workers are wet with the steam blown into the sheds, their clothes and bodies are moist, and the long hours of exposure to such uncomfortable conditions are most deleterious to physical vigor and happiness. The operatives asked that they might be allowed to work without steam-injectors and with diminished ventilation, so that the mill rooms became saturated with moisture evaporated from the bodies of the operatives. The old regulations, while forbidding more than 6 parts in 10,000 CO_2, put no limit to the wet-bulb temperature, and this often became excessive on hot summer days. The operatives were quite right. Less ventilation and a lower wet bulb is far better than ample ventilation and a high wet bulb. The permissible limit of CO_2 has now been raised to 11 parts in 10,000, and the wet-bulb temperature is to be controlled within reasonable limits.

The efficiency of workers in mills, mines, tunnels, stoke-holes, etc., is vastly increased by the provision of a sufficient draught of cool and relatively dry air, so as to prevent over-taxing of the heat-regulating mechanism. Mr. F. Green informs me that by means of forced

draught the stoke-hole of an Orient steamer is rendered the coolest place when the ship is in the tropics. The electric fan has vastly improved the conditions of the worker in the tropics. I would suggest that each clerk should have a fan just as much as a lamp on his desk. It will pay the employer to supply fans.

In the modern battleship men are confined very largely to places artificially lit and ventilated by air driven in by fans through ventilating shafts. The heat and moisture derived from the bodies of the men, from the engines, from cooking-ranges, etc., lead to a high degree of relative moisture, and thus all parts of the ironwork inside are coated with granulated cork to hold the condensed moisture and prevent dripping.

The air smells with the manifold smells of oil, cooking, human bodies, etc., and the fresh air driven in by fans through the metal conduits takes up the smell of these, and is spoken of by the officers with disparagement as "tinned" or "potted" air. This air is heated when required by being made to pass over radiators. Many of the officers' cabins and offices for clerks, typewriters, etc., in the center of the battleship, have no portholes, and are only lit and ventilated by artificial means. The steel nature of the structure prevents the diffusion of air which takes place so freely through the brick walls of a house. The men in their sleeping quarters are very closely confined, and as the openings of the air-conduits are placed in the roof between the hammocks, the men next to such openings receive a cold draught and are likely to shut the openings. To sleep in a warm moist "fugg" would not much matter if the men were actively engaged for many hours of the day on deck and there exposed to the open air and the rigors of sea and weather. In the modern warship most of the crew work for many hours under deck, and some of the men may scarcely come on deck for weeks or even months. Considering the conditions which pertain, it seems to be of the utmost importance that all the men in a battleship should be inspected at short intervals by the medical officers so that cases of tuberculosis may be weeded out in their incipiency. The men of every rating should do deck drill for some part of every day. In the Norwegian navy every man, cooks and all, must do gymnastic drill on deck once a day. In the case of our navy, with voluntary service, the men should welcome this in their own interest.

In a destroyer visited by me twelve men occupied quarters containing about 1,700 cubic feet of air. There was a stove with iron pipe for chimney, from which fumes of combustion must leak when in use, and a fan which would not work. When the men are shut down the moisture is such that boots, etc., go moldy, and the water drips off the structure. The cooling effect of the sea-water washing over the steel shell of the boat is beneficial in keeping down the temperature in these

confined and ill-ventilated quarters. On the maneuvering platform in the engine-room the wet-bulb temperature reaches a very high degree owing to the slight escape of steam round the turbines. Commander Domvile was kind enough to send me the wet and dry bulb temperatures taken there on a number of days. The wet bulb was found to be never below 80° F., sometimes reached 95° and even 98° F. It is impossible for officers to work at these temperatures without straining the heat-regulating mechanism of the body and diminishing their health and working capacity. If such wet-bulb temperatures are unavoidable, means should be provided, such as fans, which would alleviate the discomfort and fatigue caused thereby. A supply of compressed air fitted with a nozzle might be arranged and used occasionally to douche the body with cool air. I have tried this plan and found it very effectual, and can recommend the compressed-air bath as the substitute for a bracing cold wind.

The suitability of the clothing is of the greatest importance, not only to the comfort but to the efficiency of man as a working machine, *e. g.*, power of soldiers to march. On a still day the body is confined by the clothes as if by a chamber of stagnant air, for the air is enclosed in the meshes of the clothes and the layer in contact with the skin becomes heated to body temperature and saturated with moisture.

The observations of Pembrey show that himself and four soldiers, marching in drill order on a moderately warm day, lost more water and retained more water in their clothes than on another similar day when they worked with no jacket on. The average figures were loss of moisture 1,600, against 1,200 grams, and water retained in clothes 254, against 109 grams. With no jacket the pulse was, on the average, increased 28, against 41 in drill order, and rectal temperature 1°, against 1°.5 F. The taking off of the jacket or throwing open of the jacket and vest very greatly increase the physiological economy of a march. It is absurd that on a hot summer day Boy Scouts should march with a colored scarf knotted round their necks. Nothing should be worn for ornament or smartness which increases the difficulty of keeping down the body temperature. The power to march and the efficiency of an army depend on prevention of heart stagnation and avoidance of fatigue of the heart.

I conclude then, that all the efforts of the heating and ventilating engineer should be directed towards cooling the air in crowded places and cooling the bodies of the people by setting the air in motion by means of fans. In a crowded room the air confined between the bodies and clothes of the people is almost warmed up to body temperature and saturated with moisture so that cooling of the body by radiation, convection and evaporation becomes reduced to a minimum. The strain on the heat-regulating mechanism tells on the heart. The pulse

is accelerated, the blood is sent in increased volume to the skin, and circulates there in far greater volume, while less goes through the viscera and brain. As the surface temperature rises, the cutaneous vessels dilate, the veins become filled, the arteries may become small in volume, and the blood-pressure low, the heart is fatigued by the extra work thrown upon it. The influence of the heat stagnation is shown by the great acceleration of the pulse when work is done and the slower rate at which the pulse returns to its former rate on resting.

The increased percentage of carbonic acid and diminution of oxygen which has been found to exist in badly ventilated churches, schools, theaters, barracks, is such that it can have no effect upon the incidence of respiratory disease and higher death-rate, which statistical evidence has shown to exist among persons living in crowded and unventilated rooms. The conditions of temperature, moisture and windless atmosphere in such places primarily diminishes the heat loss, and secondarily the heat production, *i. e.,* the activity of the occupants, together with total volume of air breathed, oxygen taken in and food eaten. The whole metabolism of the body is thus run at a lower plane, and the nervous system and tone of the body is unstimulated by the monotonous, warm and motionless air. If hard work has to be done it is done under conditions of strain. The number of pathogenic organisms is increased in such places, and these two conditions run together—diminished immunity and increased mass influence of infecting bacteria.

The volume of blood passing through, and of water vapor evaporated from, the respiratory mucous membrane must have a great influence on the mechanisms which protect this tract from bacterial infection. While too wet an atmosphere lessens evaporation, a hot dry atmosphere dries up the mucous membrane. As the immunizing powers depend on the passage of blood plasma into the tissue spaces, it is clear that a proper degree of moisture is important. The temperature, too, must have a great influence on the scavenger activity of the ciliated epithelium and leucocytes in the mucous membrane of the nose.

In the warm moist atmosphere of a crowded place the infection from spray, sneezed, coughed, or spoken out, is enormous. On passing out from such an atmosphere into cold moist air the respiratory mucous membrane of the nose is suddenly chilled, the blood-vessels constricted and the defensive mechanism of cilia and leucocyte checked. Hence the prevalence of colds in the winter. In the summer the infection is far less. We are far more exposed to moving air, and the sudden transition from a warm to a cold atmosphere does not occur. We believe that infection is largely determined by (1) the mass influence of the infecting agent; (2) the shallow breathing and diminished

evaporation from, and flow of tissue lymph through, the respiratory tract, in warm, moist confined air. Colds are not caught by exposure to cold *per se,* as is shown by the experience of Arctic explorers, sailors, shipwrecked passengers, etc.

We have very great inherent powers of withstanding exposure to cold. The bodily mechanisms become trained and set to maintain the body heat by habitual exposure to open-air life. The risk lies in over-heating our dwellings and over-clothing our bodies, so that the mechanisms engaged in resisting infection become enfeebled, and no longer able to meet the sudden transition from the warm atmosphere of our rooms to the chill outside air of winter. The dark and gloomy days of winter confine us within doors, and, by reducing our activity and exposure to open air, depress the metabolism; the influence of smoke and fog, gloom of house and streets, cavernous places of business and dark dwellings, intensify the depression. The immunity to a cold after an infection lasts but a short while, and when children return, after the summer holidays, to school and damp chill autumn days, infection runs around. The history of hospital gangrene and its abolition by the aseptic methods of Lister—likewise the history of insect-borne disease—show the great importance of cleanliness in crowded and much occupied rooms. The essentials required of any good system of ventilation are then (1) movement, coolness, proper degree of relative moisture of the air; (2) reduction of the mass influence of pathogenic bacteria. The chemical purity of the air is of very minor importance, and will be adequately insured by attendance to the essentials.

As the prevention of spray (saliva) infection by ventilation is impossible in crowded places, it behooves us to maintain our immunity at a high level. We may seek to diminish the spray output of those infected with colds by teaching them to cough, sneeze and talk with a handkerchief held in front of the mouth or to stay at home until the acute stage is past.

In all these matters nurture is of the greatest importance, as well as nature. A man is born with physical and mental capacities small or great, with inherited characteristics, with more or less immunity to certain diseases, with a tendency to longevity of life or the opposite, but his comfort and happiness in life, the small or full development of his physical and mental capacities, his immunity and his longevity of life, are undoubtedly determined to a vast extent by nurture. By nurture—use the the word in its widest sense to include all the defensive methods of sanitary science—plague, yellow fever, malaria, sleeping-sickness, cholera, hospital gangrene, etc., can be prevented by eliminating the infecting cause; smallpox and typhoid by this means, and also by vaccination; and most of the other ills which flesh is sup-

posed to be heir to can be kept from troubling by approximating to the rules of life which a wild animal has to follow in the matter of a simple, and often spare diet, hard exercise and exposure to the open air. There is nothing more fallacious than the supposition commonly held that over-feeding and over-coddling indoors promotes health. The two together derange the natural functions of the body. He who seeks to save his life will lose it.

The body of a new-born babe is a glorious and perfect machine, the heritage of millions of years of evolution.

> Not in entire forgetfulness,
> And not in utter nakedness,
> But trailing clouds of glory do we come.
> . . . . . .
> Shades of the prison house begin to close
> Upon the growing Boy.

The ill-conditioned body, anemic complexion and undersized muscles, or the fat and gross habit, the decay of the teeth, the disordered digestion, the nervous irritability and unhappiness are the result of "nurture"—not nature. In institutions children may be disciplined to vigorous health. After leaving school they are set adrift to face monotonous work in confined places, amusement in music-halls and cinema shows in place of manly exercise in the open air, injudicious diet, alcohol and tobacco—everything which the trainer of an athlete would repel.

> And custom lie upon thee with a weight
> Heavy as frost and deep almost as life.

THE PERMANENT FIREPROOFING OF COTTON GOODS[1]

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WHEN I had the honor of being asked to deliver one of the general lectures, I had no choice but to accept and yet it was at once evident to me that I should experience very great difficulty in finding a subject suitable to this occasion and interesting to the brilliant and distinguished audience which I see before me this afternoon.

This difficulty is due to the fact that, while I have always taken an interest in industrial questions and have repeatedly investigated industrial problems from the scientific point of view, my researches have, for the most part, lain in the path of pure science, and any practical application of my researches to the chemical and allied industries, I have had to leave to others.

Among the problems of technical interest which I have worked at during many years are the manufacture of artificial camphor, of "synthetic" rubber and more particularly the permanent fireproofing of cotton goods and other inflammable materials. In considering these subjects, I concluded that the problem of the manufacture of artificial camphor was too technical to be generally interesting and my friend—Professor Duisberg—wishes to introduce the subject of "synthetic" rubber into his general lecture so there remained the subject of permanent fireproofing which in many respects is perhaps as interesting and important and as difficult of accomplishment as the other problems I have mentioned. The problem of the prevention of fire has always been one of the most pressing and at the same time one of the most difficult and perplexing with which mankind has had to deal. In very early times wooden houses caught fire and were burnt down and it is said that the Romans attempted to render wood fireproof by dipping it in a bath made of vinegar and powdered clay.

This treatment, so strongly reminiscent of processes employed many years afterwards, would no doubt be effective in rendering the wood less liable to inflame, but it can hardly have had wide application because vinegar, in those days, was not easily obtained in quantity and was consequently an expensive substance. I have made a search in a number of old books with the object of discovering some other of the actual methods used in early times in connection with fireproofing and the first pamphlet on the subject which I have been able to find dates from

[1] A general lecture before the Eighth International Congress of Applied Chemistry on September 10, 1912.

1638 when Nikolas Sabattini published a remarkable paper in which he discussed the need of reform in the administration and construction of the theaters in Italy and pointed out the danger, which is always present, of fire breaking out on the stage, not only owing to the inflammable nature of the wood employed in the construction of the theater and for the decorations and scenery but also on account of the inflammability of the cotton material used in the scenery and for the dresses of the players.

He recommends, as a safeguard, that the color used in painting the theater and scenery should be mixed with clay and gypsum but says nothing about the fireproofing of the dresses.

At a considerably later date—in 1735—Wild suggested a mixture of alum, borax and sulphuric acid for the same purpose and, in 1740, Fagot, in a paper read before the Academy in Stockholm, recommended a mixture of alum and green vitriol whereas, in the Dictionnaire de l'Industrie published in the year 1786, there is a paragraph in which it is stated that a mixture of alum, green vitriol and salt is effective in making wood and other material fireproof.

After the disastrous fire in Munich on the fourteenth of January, 1823, which completely destroyed the Hof and National Theater, a large number of experiments were made with the result that the wood used in the construction of the roof and other parts of the new theater, was painted with several coats of sodium silicate and chalk.

A coating of this kind lasts for many years and, although it does not render the wood absolutely non-inflammable, it has at least this value that the incipient fire, which, as a rule, begins in quite a small way, meets with resistance at the outset, progresses but slowly and is easily extinguished.

At a somewhat later date, it was discovered that wood saturated with other salts such as, for example, copper sulphate or ammonium phosphate, acquires the property of resisting flame, but of all the salts, zinc chloride seems to be the most efficient for this purpose.

In the first place, zinc chloride has great affinity for, and, therefore, attaches itself readily to, woody fiber, and fibers of all kinds and material saturated with a solution of this salt and then dried are practically non-inflammable. This salt has also this valuable property that it is a powerful antiseptic and therefore very suitable for fireproofing the wood used in the construction of hospitals and other public institutions of a similar nature.

But I do not propose to address you this afternoon at any length on the subject of the fireproofing of wood and other building materials, a subject on which I have made comparatively few experiments and of which I, therefore, have little practical knowledge.

What I wish to discuss, and I hope that the subject will prove in-

teresting to you all, is the problem of the permanent fireproofing of wearing materials and especially of cotton and cotton goods and by permanent fireproofing I mean protection which is not removed when the materials are subjected to the ordinary domestic wash.

Many disastrous accidents are on record which have been brought about by clothing catching fire: sometimes it is the case of a child whose garments have come in contact with a spark or lighted match and sometimes disasters of much greater magnitude have resulted from the ignition of costumes made of tow or other inflammable material on the occasion of charity entertainments or fancy dress balls.

It has long been recognized that impregnation with certain salts very much reduces and indeed may entirely destroy the liability of cotton goods to inflame and, of these fireproofing agents, I may perhaps be allowed to refer to a few only of the better known and more efficient. If a garment, after washing in the ordinary way, is rinsed in a solution containing alum or is starched with a starch containing a proportion of alum, the material, after drying, shows a marked reluctance to ignite, but this treatment has many draw-backs. In the first place it makes the material very dusty, and secondly, the fireproofing is only of a temporary nature since it is at once removed by contact with water and the process must therefore be repeated every time the goods are washed. I can easily demonstrate this and, in these and all my other experiments, I purposely take only very narrow strips in order that any smoke produced may not cause inconvenience in this hall. Another solution which has been strongly recommended for the same purpose is made up with 3 parts of ammonium phosphate, 2 parts of ammonium chloride and 1 part of ammonium sulphate in about 40 parts of water. If the material after washing, is impregnated with this solution and dried, or if it is starched with starch made with the solution instead of with water, the dry material only ignites with difficulty, and, as it does not dust and is not prejudicially affected in any other way, this process has been used with advantage not only in connection with wearing material but also for the fireproofing of lace curtains and other inflammable decorations. But in this case also, the fireproofing agents employed are all soluble in water and one washing is sufficient to remove them entirely, leaving the goods at least as inflammable as before. The process must therefore be repeated every time the goods are washed and this means expense which, in the long run, becomes considerable.

But a much more serious drawback to processes of this kind is the trouble they entail since, in order to fireproof the garment the washerwoman must have alongside the ordinary wash tub, a second tub containing the fireproofing solution and this complication, added to the expense of the salts, has been shown to be so serious that processes of this kind are quite impracticable, especially in the homes of the poor.

Again, unless the materials or garments after washing, have been dried before immersion in the fireproofing solution, this solution can not be kept uniform since, each garment being wet when put in leaves the solution weaker than before and therefore of less protective value. To dry each garment between the washing and the fireproofing entails so much trouble and labor and expense that it would obviously prevent any general adoption of the practise. Although the substances I have mentioned and the salts of ammonium in particular, possess in a high degree the property of rendering material fireproof, there is one substance which confers the property of resisting fire to cotton goods in such a remarkable degree that it has long attracted attention and must be specially mentioned, and that is sodium tungstate.

A piece of muslin soaked in a weak solution of sodium tungstate and then dried is practically non-inflammable but unfortunately this salt is again so excessively soluble in water that a mere rinsing in clean water is sufficient to remove it completely and the fireproofing is lost. And this applies not only to sodium tungstate but also to all the other salts which have, from time to time, been recommended for fireproofing purposes; the result is not permanent because the proofing is at once removed when the goods are washed in the ordinary way.

The problem on which I was engaged for several years and which has now been successfully solved, in a very simple manner, was that of attempting to discover some process which not only made the goods non-inflammable but also *permanently* non-inflammable, and the researches on this subject were originally started in connection with flannelette, a material very largely and widely used for clothing, especially by the poorer classes, and one of the most, if not the most, inflammable of all cotton goods.

Flannelette may be briefly described as a kind of calico the surface of one or both sides of which has been "carded" or "raised" into a nap, the result being that the surface of the calico becomes covered with a fluff of minute fibers somewhat resembling a thin layer of cotton wool. This effect is produced by subjecting the surface of the calico to the action of a series of revolving rollers covered with a vast number of small pieces of sharp steel wire, which tear up the surface, and the material is passed over these rollers over and over again until the required amount of nap has been raised. The result of this superficial covering of nap is—as everybody who has handled flannelette will know—a warm, pleasant and cosy feel and this is no doubt due to a covering of air being imprisoned by the minute fibers thus producing a layer which acts as a non-conductor much in the same way as in the case of flannel.

In the first two samples in the little book which you each received as you entered the hall are calico and flannelette and you will notice at

once the great difference in the feel between the comparatively hard flat surface of the calico and the raised surface of the flannelette.

Flannelette is indeed little, if at all, inferior to flannel as a non-conducting material and as it is very cheap and does not shrink in the wash, it has become very popular and is manufactured in enormous quantities and almost universally used for the clothing of children, especially in the homes of the poorer classes.

But it was not long before its increasing use showed unmistakably that it has one terrible drawback—the nap, which is its peculiar feature, makes it highly inflammable and much more so than the calico from which it was manufactured.

Flannelette is in fact, as I have already said, very much like calico on the surface of which a thin layer of cotton wool has been spread and this layer is, of course, highly inflammable.

I can easily demonstrate the difference in the inflammability of calico and flannelette by applying a light to strips of each, when it will be seen that while calico burns in the ordinary way, in the case of flannelette, the flame flashes over the whole surface of the fluffy cotton layer and travels with extraordinary rapidity.

It is, of course, this property which makes flannelette one of the most dangerous of materials for clothing purposes. The alarming frequency of deaths by burning due to the wearing of flannelette became common knowledge, the coroners all over Great Britain repeatedly called attention to the matter and by degrees the agitation against its use for clothing became so persistent that the Coroners' Committee of the Home Office was directed to inquire into the matter.

The committee recognized that whilst, to quote the words of their report, "We think the common opinion attributing to it (flannelette) a large share of the blame (of burning accidents) is not far wrong" that it was impossible to prohibit its use without causing great hardship, especially to the poor. Several years before this inquiry was held, one of the largest firms of flannelette manufacturers in Manchester, Messrs. Whipp Bros. and Tod, becoming alarmed at the frequent occurrence of fatal burning accidents and fearing lest these might lead to the prohibition of the sale of the material, came to me and asked whether I would undertake a series of experiments with the object of endeavoring to find a remedy for this state of things, and, after looking carefully into the matter, I consented to do what I could. That the problem was a difficult one from many points of view will be readily understood if I briefly state the conditions which had to be kept constantly in mind while the experiments were being carried on. A process to be successful must in the first place not damage the feel or durability of the cloth or cause it to go damp as so many chemicals do, and it must not make it dusty. It must not affect the colors or

the design woven into the cloth or dyed or printed upon it; nothing (such as arsenic antimony, or lead) of a poisonous nature or in any way deleterious to the skin, may be used and the fireproofing must be permanent, that is to say, it must not be removed, even in the case of a garment which may possibly be washed fifty times or more. Furthermore, in order that it may have a wide application, the process must be cheap. What was really to be aimed at was to treat the flannelette in such a way that it acquired practically the properties of wool, which, for all ordinary purposes, may be taken as the standard of a safe material. Apart from the other conditions which I have laid down, when one considers the vigor with which the ordinary washerwoman scrubs garments with soap, not infrequently with the assistance of the scrubbing brush, and takes into account the wonderful mechanical appliances now so largely used for washing clothes with the least expenditure of time, it will not be thought surprising that the discovery of a process of fireproofing sufficiently permanent to resist all these conditions seemed to me at first to be almost an impossibility.

In describing the course of the research, I may perhaps be allowed to give a brief sketch of the development of the subject and to outline the reasoning which led to the institution of the various experiments. Some idea of the difficulty of the subject will be gathered when I say that Mr. Samuel Bradbury, who so ably assisted me in the work and has kept a record of each experiment, tells me that upwards of 10,000 separate burning tests were made before the solution of the problem was reached. Besides these, a great number of further experiments have since been made to see whether an even cheaper process than that which has now been in commercial use for nearly ten years could be discovered.

I suppose that every one would agree that, at the outset of the experiments, the condition which seemed most difficult of realization was that of finding a substance which not only fireproofs, but which during the process becomes so permanently fixed that it will prove to be absolutely resistant to washing with soap and water or mechanical rubbing. Obviously the substance which is to fulfil these conditions must, in the first place, be insoluble in water and secondly in order that it is not liable to be removed by mechanical rubbing and does not render the cloth dusty, it must be fixed in the fiber and not be merely on the surface. I have already explained that when calico is dipped in a dilute solution of sodium tungstate, and then dried the material possesses in a remarkable degree the property of resisting flame and then again alum has often been recommended for the same purpose. Now when solutions of sodium tungstate and alum are mixed, an insoluble aluminum tungstate is produced and it is clear that, if this insoluble salt could be fixed in the fiber, the material would certainly

be fireproof. It furthermore seemed reasonable to suppose that, as the salt is insoluble in water, it would remain in the fiber even after several washings and therefore that permanent fireproofing might be achieved in this manner.

A piece of flannelette was therefore soaked in sodium tungstate and, after passing through rollers, to remove the excess of the solution, left for a considerable time in a solution of alum. It was then squeezed, dried and was passed through the same process again with the result that the material became almost as fire-resistant as asbestos. When, however, the piece was thoroughly washed with soap and water, it was most disappointing to find that the greater part of the fireproofing was removed during the first washing and after several washings the material was little better than the original flannelette.

While this unexpected result was being investigated, it was noticed that aluminum tungstate is soluble in acetic acid and is reprecipitated when the acetic acid is removed by evaporation or by the action of steam and as the precipitate formed seemed granular in appearance, it was thought that this process, if applied to the flannelette, might yield a better result than the process of double decomposition had done. Accordingly, a solution was made up of sodium tungstate, aluminum sulphate and enough acetic acid to dissolve the precipitate, the flannelette was thoroughly soaked in this solution, dried and then placed in an ordinary steamer and subjected to the action of steam until the odor of acetic acid could no longer be detected.

The material was, of course, non-inflammable and when it was washed it was found that this property was distinctly more resistant to soap and water than was the case in the first experiment, but after several vigorous washings almost every trace of the fireproofing had disappeared. These negative results seemed therefore to indicate that aluminum tungstate was not suitable for the purpose of permanent fireproofing. On the other hand, the failure of this salt was possibly due to some peculiarities in its specific properties and was not considered valid evidence that other insoluble tungstates might not combine more completely with the fiber and thus resist removal by washing.

A careful examination of the tungstates was therefore made and such insoluble salts only selected for experiment which, like aluminum tungstate, are colorless, since it is obvious that a fireproofing agent to be of any use must be capable of application to white cloth without staining it. Several hundred pieces of flannelette were treated under the most varied conditions with all sorts of combinations which it was known would precipitate insoluble tungstates in the fiber, but in no case was a satisfactory result achieved.

However, a fact was noticed which afterwards proved to be of value, and it was this, that, of all the salts, the tungstates of zinc and tin

seemed to offer the most resistance to washing with soap and water. Thus, when the material had been thoroughly saturated with a solution made up of sodium tungstate, zinc sulphate and enough acetic acid to prevent the precipitation of the zinc tungstate, and the goods after drying were thoroughly steamed, the fireproofing was certainly fixed to some extent, since it required several washings before the material burnt at all freely. But no amount of variation of the conditions produced a really good result and this combination had therefore to be abandoned. Since the tungstate proved to be unsuitable to the exacting conditions of the problem, a general examination of almost every variety of salt, including ferrocyanides, aluminates, arseniates, antimoniates, zincates and plumbates was made. Many of these could not be employed in connection with wearing apparel in any case because of their poisonous nature, but it was thought that this general examination, which lasted several months, might yield some indication of the type of salt likely to prove resistant to soap and water, if, indeed, such type of salt existed at all. And as a matter of fact these experiments did prove to be most valuable, because when the results were all tabulated, the generalization gradually became apparent that certain soluble salts such as aluminates, antimoniates, zincates and plumbates, in which the oxide of the metal functions as an acid, yielded precipitates, especially with zinc and tin salts which exhibited much greater resistance to washing than the commoner insoluble salts, such as barium sulphate or magnesium phosphate. This generalization ultimately led to a very careful examination of the salts of tin, because, as is well known, the oxides of tin dissolve in alkalis to form stannites and stannates and tin therefore belongs to the class of salts just mentioned and it very soon became evident that these salts do actually possess the power of combining with the fiber to a greater extent than any of the salts which had previously been experimented with.

In one experiment it was noted that a piece of flannelette, which had first been saturated with a solution of sodium stannate and dried, and afterwards similarly treated with a solution of zinc chloride, was quite non-inflammable. After the sample had been subjected to a vigorous washing with soap and water a considerable amount of the fireproofing still remained, because, when a light was applied to the cloth, it only ignited with difficulty, burned very slowly, and either went out of itself or was easily extinguished on shaking the material.

This development was so promising that the experiment was repeated in a great variety of ways, but, although several results were obtained which were much better than anything which had been seen before, it was disappointing to find that in all the cases the greater part of the fireproofing was lost after repeated washings.

In a later series of experiments the first solution was again sodium

stannate and the second consisted of sodium tungstate, zinc acetate and sufficient acetic acid to prevent precipitation of the zinc tungstate formed. The result in this case was so good, the material being practically as safe as wool, even after repeated washings, that the first commercial permanently fireproofed flannelette which was placed on the market was made on these lines.

It was soon found, however, that the material thus treated had two serious drawbacks: it had a tendency to go damp, and an unpleasant smell of acetic acid remained, even though the material had been steamed and washed, after the fireproofing process, before being sent out. And apart from these two faults, the fireproofing was still not sufficiently permanent and the cost of the process was too great for it to be considered a satisfactory one.

A further series of careful comparative tests seemed to indicate that the undoubted advance which had been made was mainly due to the use of the stannate, and it was therefore decided to carry out a series of experiments using salts of tin exclusively.

The fabric, after being treated with sodium stannate as before, was, in the earlier of these experiments, passed through a fixing bath containing stannous chloride. A very permanent fireproofing was again obtained, but the stannous chloride being a reducing agent, tended to destroy or affect the colors of the material, and the process would, therefore, be generally applicable only to white cloth.

In order to get over this difficulty stannic chloride was employed, instead of the stannous salt, as the fixing agent, and to avoid any tendering of the material care was taken that the stannic chloride solution should be of such a strength that a little stannate was left unchanged in the material.

An excellent fireproofing was again obtained, for not only did the material show very little tendency to inflame, after it had been washed several times with soap and water, but it had also in such other respects as appearance and feel almost ideal properties, the only objectionable feature being a slight tendency to dust on rubbing and shaking. Now in this particular experiment, in which sodium stannate and stannic chloride had been employed together, the substance which must have been produced in the fiber, and to which the fireproofing must therefore have been due, is stannic oxide, and it seemed clear that this oxide or its hydrate must have some remarkable power of combining with, or attaching itself to, the fiber which enables it to resist removal by washing and rubbing.

But this process still left something to be desired on the score of economy. A certain amount of the tin was undoubtedly wasted, for, in addition to that lost through a portion of the stannate being left unfixed, it was noticed that a considerable amount of the tin oxide

which was formed by the action of the alkali of the stannate on the stannic chloride, was not permanently fixed in the fibers of the material, and was therefore removed during the subsequent washing. Tin is so expensive that, in a process to be commercially successful, this loss must obviously be avoided.

There are many ways in which stannic oxide may be precipitated from sodium stannate and one of these, commonly used in ordinary analytical chemistry, consists in adding certain soluble salts, such as sodium sulphate or ammonium nitrate to the solution of the stannate, when the whole of the tin is precipitated as oxide or hydrate. In order to find out whether some process of this kind would precipitate this oxide in such a condition that it would remain permanently fixed in the fiber, a number of pieces of flannelette were soaked in sodium stannate and, after thoroughly drying, separately passed through various solutions containing sodium or ammonium salts at the ordinary temperature and at temperatures up to the boiling point. Although, as was to be expected, the results were not uniformly good, a certain degree of permanent fireproofing was always achieved and consequently the matter was systematically followed up with the result that a process was gradually evolved which yielded material possessing quite remarkable properties. The process is briefly this:

The flannelette (or other material) is run through a solution of sodium stannate of approximately 45° Tw. in such a manner that it becomes thoroughly impregnated. It is then squeezed to remove the excess of the solution, passed over heated copper drums in order to thoroughly dry it, after which it is run through a solution of ammonium sulphate of about 15° Tw. and again squeezed and dried.

Apart from the precipitated stannic oxide, the material now contains sodium sulphate and this is removed by passage through water; the material is then dried and subjected to the ordinary processes of finishing. A long series of trials, carried out under the most stringent conditions, have conclusively proved that material, subjected to this process is permanently fireproofed. No amount of washing with hot soap and water will remove the fireproofing agent, or in other words, the property of resisting flame lasts so long as the material itself lasts. I will demonstrate this by exhibiting four different specimens: (*i*) material as it leaves the process and before washing, (*ii*) material which has been washed ten times by hand, (*iii*) material washed 20 times in a machine in a laundry and (*iv*) a portion of a garment which has been in actual use for 2 years, washed every week and is, as you see, in rags. This extraordinary property of resisting soap and water seems to me to indicate that the oxide of tin is not present merely as an insoluble precipitate in the cloth but must have entered into some actual combination with the fiber, yielding a compound which is not broken down by

the action of the weak alkali of the soap. But a matter of hardly less importance from the practical point of view is that the material is not only permanently fireproofed by the process I have just described, it also retains and acquires properties which make it as perfect a material in all other respects as could be desired. In the first place the treatment has no effect on the delicate colors which are now so generally employed in connection with the manufacture of flannelette and other cotton goods and very careful experiments have demonstrated the fact that the insoluble tin compound in the fiber has not the slightest deleterious action on the most delicate skin. In addition, the presence of the tin compound in the pores gives the cloth a softer and fuller feel than that of the original flannelette and what perhaps is the most unexpected result is the fact that the material is considerably strengthened by the process.

A series of tests made by the Manchester Chamber of Commerce proved that the tensile strength of flannelette is increased nearly 20 per cent. as the result of the introduction of the tin compound into the fiber.

Further and very exhaustive tests made at the Municipal School of Technology, Manchester, on a machine specially designed for testing the wearing properties of fabrics, showed an even greater gain in durability in the case of the fireproofed flannelette. These separate and independent tests conclusively showed that the increase in strength and durability was approximately equal to the cost of the fireproofing treatment so that garments made from the permanently fireproofed flannelette are, as a matter of fact, no dearer than those made from ordinary flannelette and are at the same time as safe as if made from flannel. Some of these properties and statements may be easily tested by each of you independently with the samples in the little book which you received on entering the hall.

This permanently fireproofed flannelette is now manufactured on the large scale by Messrs. Whipp Bros. and Tod in Manchester under the name of "Non-Flam" and, although its introduction has been slow, it is being increasingly used and will, in all probability, ultimately entirely replace the ordinary inflammable variety. One of the difficulties experienced in connection with its general introduction is the fact, that, owing to the high price of tin, which is now quoted at about £210 or $1,050 per ton, the cost of the process is not inconsiderable but, even with tin at this high price, the extra cost is not more than 1 d. (2 cents) per yard or about 1½ d. or 2 d. (3–4 cents) for a child's garment. I have here on the table, rolls of "Non-Flam" of different qualities so that any one who wishes for a larger sample than is contained in the little book can easily obtain it.

It is hardly necessary for me to say that this process can be applied

to any cotton fabric and is especially valuable in connection with muslin because this material is so often used, especially on the stage, for dresses which, on account of their flimsy nature, are naturally highly inflammable. I have here two strips of the same muslin, one of which has been treated by the "Non-Flam" process without in any way affecting its ordinary properties and was then washed ten times and the difference in inflammability of the two samples is very striking. Whilst the first sample is highly dangerous, it is difficult to imagine that harm could come to any one who happened to be dressed in the treated material even if, by accident, a lighted match came in contact with the dress. Another direction in which the process may be used with great advantage is in connection with lace curtains. Many disastrous fires have occurred by reason of the ignition of lace curtains and there can be no doubt that the greater majority of these would have been avoided if the curtains had been treated by the "Non-Flam" process. As an example of this, I have here a strip of lace curtain which has been subjected to the process and then washed a number of times and it will be seen that if such material did accidentally come in contact with a lighted match, the danger of fire is reduced to a minimum because even supposing the material did catch fire, the flame is put out at once by the least shake.

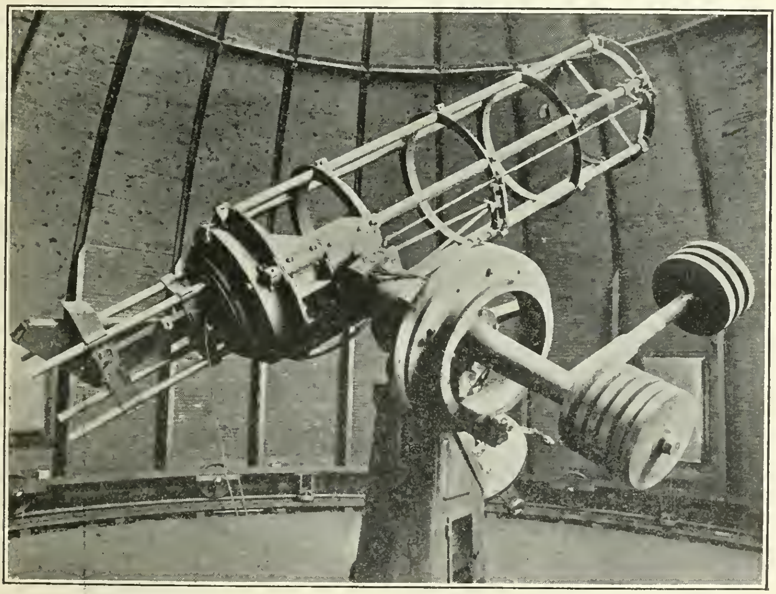
It seems to me that it is obvious that, if this process or some other process capable of giving the same protection from fire, was adopted in the case of all inflammable cotton goods and especially in the case of material used for garments, many disastrous fires and the appalling loss of life especially among young children, might be avoided and it is for this reason that I have ventured to bring the subject of the permanent fireproofing of cotton goods to your notice this afternoon.

THE PROGRESS OF SCIENCE

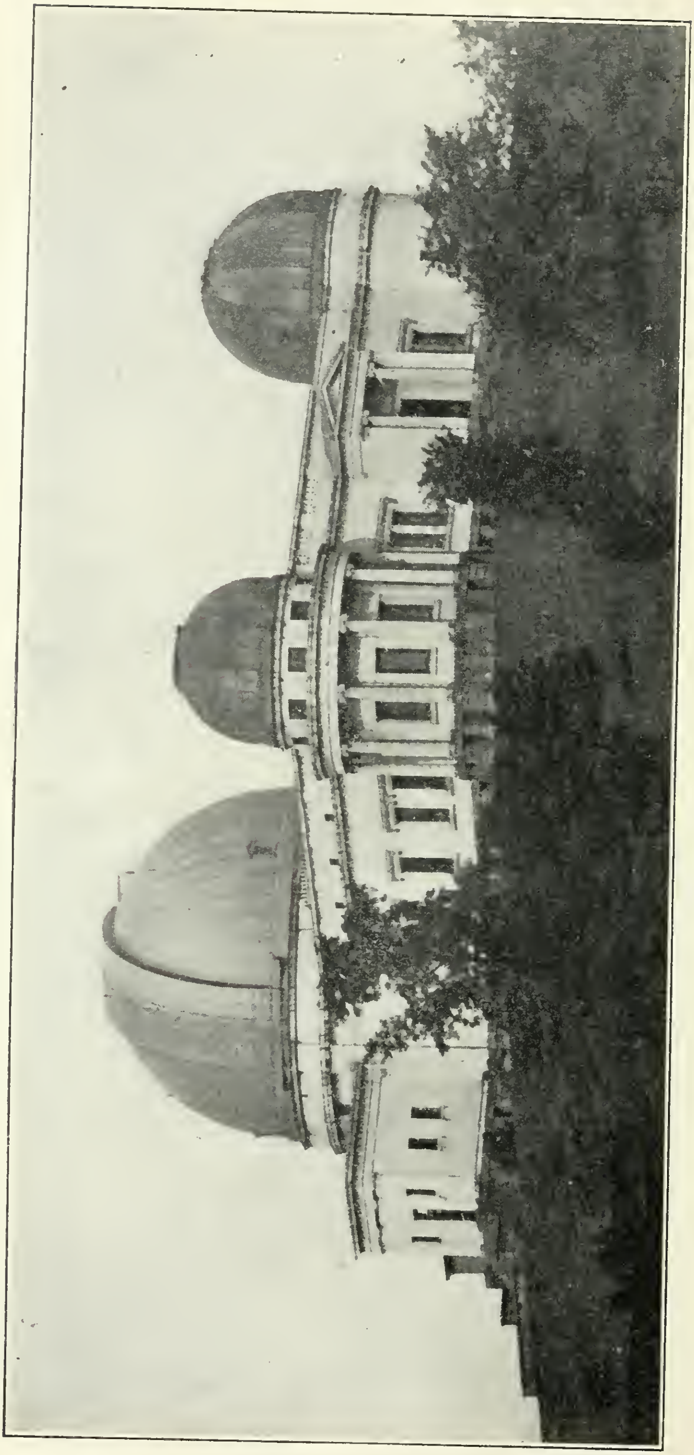
DEDICATION OF THE NEW ALLEGHENY OBSERVATORY

THE new Allegheny Observatory in Riverview Park, Pittsburgh, was dedicated on the afternoon of August 28, in the presence of the members of the Astronomical and Astrophysical Society of America and of many of the Pittsburgh friends of the institution. The new building and its contents have cost about $300,000, the equipment being in quite the first rank. The new site is higher than the old and is farther removed from the city. As the observatory now stands in a large park, it will probably be free from serious encroachments in the future.

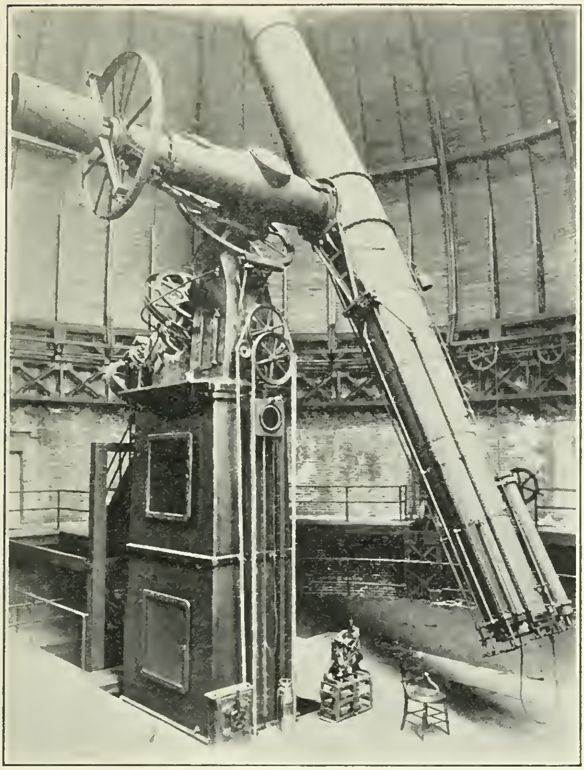
The Allegheny Observatory dates back to 1859, in which year a number of citizens of Pittsburgh and Allegheny organized the "Allegheny Telescope Association" and purchased a 13-inch refracting telescope. Although this telescope was then the third largest in the world, the sole purpose of its owners was "star-gazing," and no attempt was made to use the telescope otherwise until 1867. In that year, chiefly through the efforts of William Thaw, the observatory became the astronomical department of the Western University of Pennsylvania, now the University of Pittsburgh. In the same year the trustees secured the services of Samuel Pierpont Langley as director, who at once set on foot the series of solar investigations that soon gave the observatory and its director an international reputation. In the course of this work Langley invented the bolometer and succeeded in mapping the solar spectrum far into the infra-red. It was at Allegheny, too, that he began his researches on



THE KEELER MEMORIAL REFLECTOR.



THE NEW ALLEGHENY OBSERVATORY.



THE THAW PHOTOGRAPHIC REFRACTOR.

mechanical flight, now recognized as having formed the basis for present-day success in this field.

After Langley had been called to the secretaryship of the Smithsonian Institution at Washington, he was succeeded at Allegheny by his former assistant, James Edward Keeler. His short directorship was marked by the brilliant proof of the meteoric composition of Saturn's rings, one of the best planned and most striking observations of modern astronomy. Keeler persistently urged the necessity of removing the observatory from its original site, upon which the rapidly growing city had by this time seriously encroached. Steps to bring about this removal were under way, but they were temporarily halted in 1898, when Keeler was called to the directorship of the Lick Observatory. But shortly afterwards these efforts were vigorously renewed by Dr. John A. Brashear, who has been chairman of the observatory committee since 1894. The new observatory as it stands to-day is in large measure a tribute to the respect and affection in which Dr. Brashear is held by the people of Pittsburgh.

The plans for the new observatory and its equipment are due to Keeler's immediate successor, Professor F. L. O. Wadsworth, and to the present director, Dr. Frank Schlesinger. The principal instruments are the old 13-inch refracting telescope, a 30-inch reflecting telescope (a memorial to Keeler), and a 30-inch refracting telescope (a memorial to William Thaw and his son, William Thaw, Jr.). The last of these telescopes is not quite complete, as the objective remains to be supplied.

INTERNATIONAL SCIENTIFIC CONGRESSES MEETING IN AMERICA

The progress of international cooperation in scientific work is exhibited by the large and growing number of congresses holding migratory meetings in different countries, and the greater share taken by America in the advancement of science is born witness to by the fact that these congresses meet with increasing frequency in the United States. The Eighth International Congress of Applied Chemistry has just closed its meeting in Washington and New York, and the Fifteenth International Congress of Hygiene and Demography will be meeting in Washington when this issue of the Monthly appears. These are among the most important of such gatherings. Chemistry is the science which, owing to its industrial applications, attracts the largest number of workers, and hygiene and demography occupy an equally important place in our modern civilization.

There were enrolled about 4,500 members for the Congress of Applied Chemistry, of whom 2,173, coming from thirty different countries, were in attendance. They presented 724 papers before the twenty-four sections and the joint sessions of these sections. 570 of the papers were printed in advance in 24 volumes and were distributed to members at the time of the meeting. After preliminary meeting and entertainments in New York City, the congress went to Washington by special train, where the members were received by the president of the United States, who acted as patron of the congress. After the return to New York, the sectional meetings were organized and there were many public lectures, receptions, dinners and excursions. The public lectures included the following: M. Gabriel Bertrand, on "Chemical biology"; Dr. Samuel Eyde, on "The oxidation of atmospheric nitrogen, and the resulting industries in Norway"; Dr. Carl Duisberg, on "The synthetic production of rubber"; Dr. Giacomo Ciamician, on "The photo-chemistry of the future"; Professor William Henry Perkin, on "The permanent fireproofing of cotton goods," which is printed in this issue of the Monthly. The entertainments included receptions at the American Museum of Natural History, the Metropolitan Museum and the Chemists' Club; afternoon teas at Columbia University and the College of the City of New York; an excursion up the Hudson, and a grand banquet at the Waldorf-Astoria. At the conclusion of the meeting excursions were arranged to Chicago and to the Pacific coast. Dr. Edward W. Morley was honorary president of the congress and Dr. Wm. H. Nichols was the active president, to whom with the other officers the successful organization and conduct of the congress was in large measure due. The ninth congress will be held three years hence at St. Petersburg under the presidency of Professor Paul T. Walden.

The Fifteenth International Congress of Hygiene and Demography, under the presidency of Dr. Henry P. Walcott, of Massachusetts, will undoubtedly be equally notable. An important and interesting scientific program and exhibit have been arranged. Some 300 German physicians have already arrived in New York to attend the meetings. Mention should also be made of the International Otological Congress at Boston under the presidency of Dr. Clarence J. Blake, which though smaller and attracting less attention, has brought to this country a number of distinguished foreign otologists. Two further gatherings of foreign scientific men in this country deserve mention—the transcontinental excursion of the American Geographical Society and the dedication of the Rice Institute. The former is quite unique in character. The American Geographical Society, to celebrate the

THE LATE PROFESSOR L. J. TROOST, OF THE UNIVERSITY OF PARIS, THE DISTINGUISHED CHEMIST, IN THE UNIFORM OF THE PARIS ACADEMY OF SCIENCES.

sixtieth anniversary of its foundation and the completion of its new building, planned a transcontinental excursion under the conduct of Professor William M. Davis, of Harvard University, to which the leading geographical societies of Europe were invited to appoint delegates as guests. There were about forty acceptances, including many of the leading geographers of the world, who with their American colleagues are at present engaged in an excursion across the continent lasting about two months. An international character has been given to the inauguration of the Rice Institute at Houston, Texas, by inviting twelve distinguished foreign scientific men and scholars to prepare each three lectures for the proceedings of the opening festival, to be published in a series of volumes which will be issued in commemoration of the

occasion. Among the lecturers who will be present are Professor Emil Borel, of Paris; Professor Hugo de Vries, of Amsterdam; Professor Wilhelm Ostwald, lately of Leipzig; Sir William Ramsay, of London, and Professor Vito Volterra, of Rome.

While a larger group of foreign scientific men are in this country than ever before, a considerable number of American scientific men have attended three international congresses held in England—the First International Congress of Eugenics, to which reference has already been made in this journal; the International Congress of Entomology at Oxford, and the International Congress of Mathematicians at Cambridge. The meeting of the British Association for the Advancement of Science at Dundee has also assumed international proportions, in view of the large number of foreign men of science in attendance.

THE ADDRESS OF THE PRESIDENT OF THE BRITISH ASSOCIATION

The presidential address before the British Association for the Advancement of Science given by Professor E. A. Schäfer, of the University of Edinburgh, at Dundee, on September 4 has attracted much attention in view of the popular interest in questions concerned with the nature, origin and maintenance of life. While the address does not contain new facts or theories, it is a clear and excellent statement of the chemico-mechanical explanation of life. The entire address was published in the issue of *Science* for September 6. We may quote several paragraphs, which are characteristic of the line of argument:

"It is not so long ago that the chemistry of organic matter was thought to be entirely different from that of inorganic substances. But the line between inorganic and organic chemistry, which up to the middle of the last century appeared sharp, subsequently became misty and has now disappeared. Similarly the chemistry of living organisms, which is now a recognized branch of organic chemistry, but used to be considered as so much outside the domain of the chemist that it could only be dealt with by those whose special business it was to study 'vital' processes, is passing every day more out of the hands of the biologist and into those of the pure chemist.

"Somewhat more than half a century ago Thomas Graham published his epoch-making observations relating to the properties of matter in the colloidal state: observations which are proving all-important in assisting our comprehension of the properties of living substance. For it is becoming every day more apparent that the chemistry and physics of the living organism are essentially the chemistry and physics of nitrogenous colloids. Living substance or protoplasm always, in fact, takes the form of a colloidal solution. In this solution the colloids are associated with crystalloids (electrolytes), which are either free in the solution or attached to the molecules of the colloids. Surrounding and enclosing the living substance thus constituted of both colloid and crystalloid material is a film, probably also formed of colloid, but which may have a lipoid substratum associated with it (Overton). This film serves the purpose of an osmotic membrane, permitting of exchanges by diffusion between the colloidal solution constituting the protoplasm and the circumambient medium in which it lives. Other similar films or membranes occur in the interior of protoplasm. These films have in many cases specific characters, both physical and chemical, thus favoring the diffusion of special kinds of material into and out of the protoplasm and from one part of the protoplasm to another. It is the changes produced under these physical conditions associated with those caused by active chemical agents formed within protoplasm and known

as *enzymes*, that effect assimilation and disassimilation. Quite similar changes can be produced outside the body (*in vitro*) by the employment of methods of a purely physical and chemical nature. It is true that we are not yet familiar with all the intermediate stages of transformation of the materials which are taken in by a living body into the materials which are given out from it. But since the initial processes and the final results are the same as they would be on the assumption that the changes are brought about in conformity with the known laws of chemistry and physics, we may fairly conclude that all changes in living substance are brought about by ordinary chemical and physical forces.

"Should it be contended that growth and reproduction are properties possessed only by living bodies and constitute a test by which we may differentiate between life and non-life, between the animate and inanimate creation, it must be replied that no contention can be more fallacious. Inorganic crystals grow and multiply and reproduce their like, given a supply of the requisite pabulum. In most cases for each kind of crystal there is, as with living organisms, a limit of growth which is not exceeded, and further increase of the crystalline matter results not in further increase in size but in multiplication of similar crystals. Leduc has shown that the growth and division of artificial colloids of an inorganic nature, when placed in an appropriate medium, present singular resemblances to the phenomena of the growth and division of living organisms. Even so complex a process as the division of a cell-nucleus by karyokinesis as a preliminary to the multiplication of the cell by division—a phenomenon which would *primâ facie* have seemed and has been commonly regarded as a distinctive manifestation of the life of the cell—can be imitated with solutions of a simple inorganic salt, such as chloride of sodium, containing a suspension of carbon particles; which arrange and rearrange themselves under the influence of the movements of the electrolytes in a manner indistinguishable from that adopted by the particles of chromatin in a dividing nucleus. And in the process of sexual reproduction, the researches of J. Loeb and others upon the ova of the sea-urchin have proved that we can no longer consider such an apparently vital phenomenon as the fertilization of the egg as being the result of living material brought to it by the spermatozoon, since it is possible to start the process of division of the ovum and the resulting formation of cells, and ultimately of all the tissues and organs—in short, to bring about the development of the whole body—if a simple chemical reagent is substituted for the male element in the process of fertilization. Indeed, even a mechanical or electrical stimulus may suffice to start development. *Kurz und gut*, as the Germans say, vitalism as a working hypothesis has not only had its foundations undermined, but most of the superstructure has toppled over, and if any difficulties of explanation still persist, we are justified in assuming that the cause is to be found in our imperfect knowledge of the constitution and working of living material. At the best vitalism explains nothing, and the term 'vital force' is an expression of ignorance which can bring us no further along the path of knowledge. Nor is the problem in any way advanced by substituting for the term 'vitalism' 'neo-vitalism,' and for 'vital force' 'biotic energy.' 'New presbyter is but old priest writ large.'"

SCIENTIFIC ITEMS

We record with regret the deaths of Dr. W J McGee, known for his contributions to geology, anthropology and the conservation of natural resources; of Dr. T. B. McClintic, of the United States Public Health Service, who died

of Rocky Mountain spotted fever, contracted while investigating the disease in Montana; of Dr. Humphrey Owen Jones, F.R.S., the English chemist, who with his wife was killed while ascending the Aiguille Rouge de Pentéret, in the Alps; of Mr. Robert Holford Macdowall Bosanquet, F.R.S., known for his researches in acoustics and magnetism, and of M. Lucien Lévy, the distinguished French mathematician.

Dr. Wilhelm Wundt, professor of philosophy in the University of Leipzig, one of the founders of modern psychology, celebrated his eightieth birthday on August 16, on which occasion a ''Wilhelm Wundt Stiftung,'' amounting to 7,000 Marks, was presented to the university by his students and friends.—In connection with the visit to Dundee of the British Association for the Advancement of Science, the senate of the University of St. Andrews has conferred the degree of LL.D., on sixteen foreign men of science who attended the meetings of the association. As a recognition of the president of the association, Professor E. A. Schäfer, of Edinburgh University, they are largely physiologists. The United States is represented by Dr. S. J. Meltzer, of the Rockefeller Institute of Medical Research.

The movement for the enlargement of the health activities of the United States government has resulted in the passage of a law which enlarges the functions of the Public Health and Marine-Hospital Service and changes the name to the ''United States Public Health Service.'' Under this law the new Public Health Service is given very wide authority to investigate the ''diseases of man and conditions influencing the propagation and spread thereof, including sanitation.''

// THE
POPULAR SCIENCE
MONTHLY.

NOVEMBER, 1912

A ROUND-THE-WORLD BOTANICAL EXCURSION

By Professor CHARLES J. CHAMBERLAIN
UNIVERSITY OF CHICAGO

IN August, 1911, it was my good fortune to start on an extensive botanical expedition under the auspices of the University of Chicago. The principal places visited included the Sandwich Islands, Fiji Islands, New Zealand, Australia, South Africa and Teneriffe, from which place the return to Chicago was by way of London and New York. The trip was unique in that I went entirely alone and for the purpose of making a strictly scientific investigation of the oriental cycads, a group which is not even suspected of having any economic importance.

The cycads are a gymnosperm family whose remote ancestors were abundant in the Paleozoic age, and whose less remote ancestors were abundant and had a world-wide distribution in the Mesozoic. Now, only nine genera remain, and these are confined to tropical and subtropical regions, and even there they are very local in their distribution. Four genera are western and five eastern. Of our four western genera, one ranges from Florida to Chili, two are found only in Mexico and one, only in Cuba. Of the eastern genera, one ranges from Japan to Australia, two are found only in Australia and two only in South Africa.

Having already made a ten years' study of the American forms, especially the Mexican genera, which I had collected during four visits to the Mexican tropics, it was necessary to make a similar study of the oriental forms before any safe conclusions could be drawn in regard to relationships and evolutionary tendencies. Now, with abundant material of all the genera and many of the species, a study of development and evolutionary tendencies should yield valuable results, especially since the Paleozoic ancestors are becoming well known through

the researches of various English botanists, and the Mesozoic forms are being cleared up by Professor Wieland, of Yale.

A glance at a globe or map will show that the trip was not only round the world from east to west, but also more than half the way around from north to south; further, that nearly all the journey was by water; about three months on the water, with less than three weeks by rail, and about three months on foot, or, occasionally, on horseback. Another glance at the globe will show that there was no need for any tongue but English. Why should there be a Volupuk or Esperanto, when English is becoming the universal language? Faddists may complain that English is too difficult, but most of the Maoris in New

Fig. 1. Dense Forest at Ohakune, New Zealand.

Zealand speak it, and my Maori guides spoke it even better than the average American high-school girl, for the Maori guides speak English without slang. Many of the Zulus in Africa now speak our language.

The stay in New Zealand was brief, only four weeks, but by confining my attention to the north island and following the suggestions of Professor Thomas, the botanist of the University College at Auckland, I was able to see a great deal of the botany of that peculiar region. New Zealand is well within the temperate zone, but not far enough south for severe winters, so that the landscape is green all the year round, most of the trees which shed their leaves at regular intervals being exotics like the willow and poplar. Late in September several species of willows and poplars were just coming into leaf and the

apples, peaches and cherries were in full bloom, for September is spring and January is midsummer.

There are splendid forests in the north island, but there are also large areas covered by the bracken fern (*Pteridium aquilinum*) and worthless, but very dense shrubs. When once cleared, the ground is valuable, for it is extremely fertile and the climate is ideal for raising crops. New Zealand has a hearty welcome for the settler, and the country is prosperous, so prosperous that it is hard to get a man to carry a camera or collecting outfit, for every man has a job and every boy is in school. I did not see a beggar in New Zealand. Women vote under the same conditions as men and neither the country nor the women seem to have suffered any damage.

After tramping for several days in the vicinity of Auckland, I divided the rest of my time between the forests of Ohakune and Owharoa, and the hot springs district about Rotorua.

The forests about Ohakune consist principally of two conifers, *Podocarpus* and *Dacrydium,* both large trees, reaching a diameter of six or seven feet and a height of nearly 200 feet. The branching is mostly in the upper third of the tree, and, consequently, the lumber, which resembles white pine, is very clear. The saw mill at Ohakune and the methods of lumbering are not on so large a scale as in our own forests. A six-foot log must be split before it goes to the saw.

Ohakune is a botanist's paradise. While there is no need of an ax to clear the way, the forest is like a labyrinth and one must take great care not to get lost. (Fig. 1.) In a Mexican forest one never gets lost, because the necessary use of the machete blazes a trail which one can easily follow back; but in this labyrinth at Ohakune, without any thread, I got lost within half a mile of my hotel. The tree ferns, *Dicksonia* and *Cyathea,* are abundant, while smaller ferns cover the ground and hang from the trees. In our own flora only two families of ferns, the Osmundaceæ and Polypodiaceæ, form any conspicuous feature of the landscape; but at Ohakune all the seven time-honored families are present and abundant.

Snow falls every winter, often a couple of inches deep on the level. This was a great surprise to me, for I had always associated the filmy ferns and tree ferns with rather tropical conditions, but here the snow collects in the nests formed by the crowns of the larger ferns, while it entirely covers the smaller filmy ferns. Two much-prized species, the prince's feather (*Todea superba*), a magnificent fern almost never seen in conservatories, and the kidney fern (*Trichomanes reniforme*) are very abundant here.

The object of the trip to Owharoa was to see the kauri forests (Fig. 2). The kauri (*Agathis australis*) is the most important timber tree of New Zealand and it also furnishes the gum from which dammar

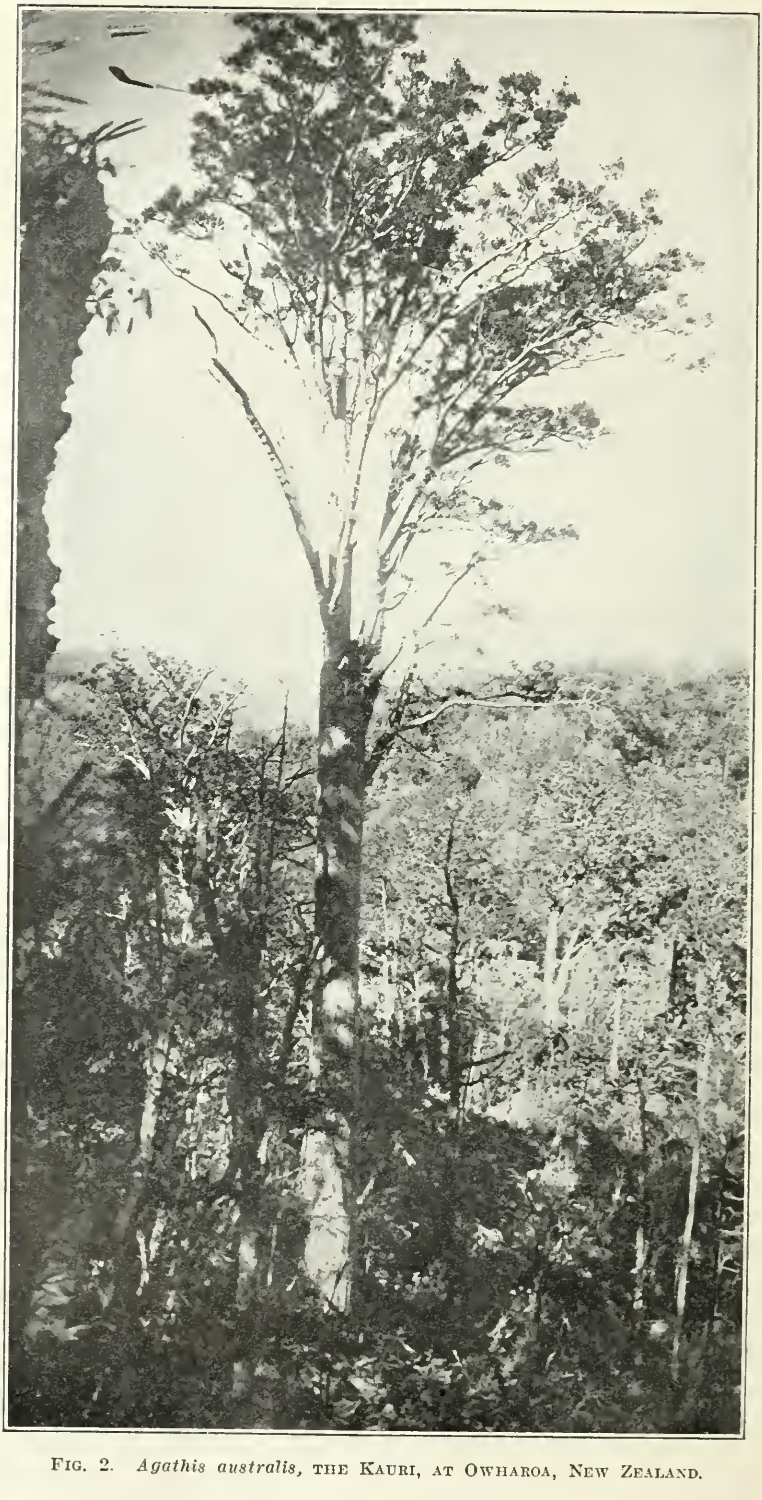


Fig. 2. *Agathis australis*, the Kauri, at Owharoa, New Zealand.

varnish is made. It reaches a height of 200 feet and a diameter of eighteen feet; but this is exceptional, specimens eight feet in diameter being regarded as very large trees. The trunk is straight and symmetrical and often measures a hundred feet up to the first branches, with a diameter of five or six feet where the branching begins; and, consequently, the lumber is very clear, closely resembling a very high grade of white pine. The forest is not at all pure, for there are many other kinds of trees, some of them not very important as timber. The methods of lumbering are as wasteful as in our own country, the fallen timber being allowed to thunder down the mountain side, tearing up all the smaller trees in its path. Since the large kauris are thousands of years old, some estimates running as high as 5,000 years, a timber company could hardly be expected to make any serious attempt at reforesting. However, there are a few government preserves, so that the big tree will not become entirely extinct. New Zealand has advanced ideas on conservation, for its recreation, forest and scenic reserves already include about 3,000,000 acres.

To the average traveler, the thermal region about Rotorua is the most interesting place in New Zealand. An oasis in the desert, or a park in a city, is easily superior to its surroundings; but a health resort in the healthiest country in the world must have inherent advantages of the highest order. Rotorua is recognized as the Baden Baden of the South Seas, and probably no springs in the world surpass those of the Rotorua district, for some springs are boiling hot, some are warm and some are cold; some are clear as crystal, and some consist of boiling, spluttering mud. The mineral properties are no less varied than the appearance and the temperature. The government has erected an extensive series of baths where one may get a good bath for as little as three pence. Whether the baths have all the curative properties claimed for them may be a question, but they are certainly refreshing and invigorating.

The region is not only uncanny and spectacular, but it is profitable both to the government and to the native; for the government manages the baths and is interested in many of the hotels for tourists, and the native Maoris find easy, lucrative employment as guides (Fig. 3). Besides, for the Maori, the natural heat boils the potatoes, fries the eggs, and furnishes hot water for the washing.

No large geysers are playing in this immediate vicinity, but vigorous thermal activity is apparent, and in 1886 the eruption of Tarawera threatened to destroy the whole Rotorua district. Numerous little lakes, of various colors and temperatures, add to the variety and beauty of the landscape (Fig. 4).

The natives of New Zealand, the Maoris, have several villages in this neighborhood. Many of them are well-to-do, have adopted Euro-

Fig. 3. General View in the Thermal Region near Rotorua, New Zealand.

pean dress and are sending their children to school. With few exceptions, the most experienced and satisfactory guides in the thermal district are young Maori women, who speak English perfectly, and, as nearly as I could determine, have about the education afforded by a first-class grammar school in our country.

On the whole, New Zealand is a remarkable country. The climate is delightful, never uncomfortably warm or uncomfortably cold, no droughts or floods, a landscape green all the year round, even deciduous exotics remaining in leaf longer than with us, a country of fertile plains, beautiful lakes and lofty forests, it is not strange that it should have the lowest death-rate in the world. In the years 1896–1907 the death-rate averaged only 9.86 per thousand. Epidemics like cholera and smallpox are unknown. In wealth, as in health, New Zealand leads the world, for in 1908 the average private wealth per capita was $1,675, and the wealth is increasing. Even teachers share in the general prosperity; I doubt whether any botanist in the world has an estate equal to that of Dr. A. P. W. Thomas, the professor of botany in the University College at Auckland.

The government is progressive, run by the people (including women) in the interest of the people; politics are not controlled by machines; there are no trusts; the government owns the railways, telegraph and telephone lines, has operated for about forty years a postal saving bank which now has about $60,000,000 in deposits, and has a life-insurance department carrying about the same amount in policies. The principal need of the country is people; there is still plenty of room, and the unusual inducements offered to colonists should attract the needed population.

The investigation for which the trip was undertaken really began when I reached Australia, for there are no cycads in New Zealand.

Australia is a large country with an area almost exactly equal to that of the United States, but with a population scarcely equal to that of Illinois. The states are few, but large, most of them being larger than Texas. They are loosely federated, but the tendency is toward closer federation. The government of the various states owns the railways and other public commodities, and the political situation resembles that in New Zealand.

The harbor at Sydney is the finest in the world. It could accommodate all the navies of all nations, and still have room enough for all the liners of the Atlantic to unload at once. While such practical features dominate in a new country, it must not be forgotten that Sydney, until very recently, had the largest pipe organ in the world, and that even now, on account of its perfect position, the organ is probably the most effective in the world. The organist is a regular officer of the city, and gives free recitals every Sunday afternoon.

Fig. 4. Lake Tikitapau, near Rotorua, New Zealand.

Other things might be mentioned to show that in the strenuous material development, the humanities have not been forgotten.

Naturally, as soon as I arrived in Sydney, I went to Professor Maiden, the director of the Botanic Gardens, well known to botanists by his work on Eucalyptus, the most characteristic of all Australian trees. I had expected to get from him some information and advice, but I was entirely unprepared for the splendid hospitality and generous assistance which I received and am still receiving, for he not only gave me valuable material from the garden and sent a competent collector to accompany me during my trips in the vicinity, but he has had the histologist of the gardens prepare some of my material for future use.

In many ways, the gardens at Sydney surpass any I had ever seen, and I have seen the gardens at Kew and Berlin. Palms from Mexico, Chili, the West Indies, the South Sea Islands and other places, grow as well here as they do in their native haunts (Fig. 5). Here, too, are tree ferns and other ferns, and gorgeous flowering trees like the flame tree (*Poinciana regia*) with its flaming red flowers, and *Jacarandra mimosæfolia,* a Brazilian tree fifty feet high and bearing great clusters of lilac-colored flowers before the leaves appear. Characteristic of all the Australian gardens are the various species of *Araucaria* and *Agathis.* Most of these beautiful trees, shrubs and ferns are too large to be grown effectively in a greenhouse and can not be grown out of doors in our latitude on account of the cold winters, so we can never hope to see in this country a garden like that at Sydney.

In addition to the botanical display there are numerous statues. The judgment displayed in their selection is beyond criticism, for you see no crude productions of local genius, but classics, like Castor and Pollux, the Farnese Hercules, the Discobolus, and others of equal merit.

An excellent museum and a large herbarium, devoted principally to Australian material, add to the scientific value of the gardens.

Three genera of cycads grow in Australia, *Cycas, Macrozamia* and *Bowenia,* the first ranging from Japan to Australia, and the other two being confined to Australia. The cycads in the gardens include all the genera of the family, except *Microcycas,* and the collection of *Macrozamia* is, beyond doubt, the finest in the world. After studying this splendid collection and spending a day at Avoca, where *Macrozamia spiralis* forms such dense thickets that one can hardly crowd his way through, I went to Brisbane, 725 miles north of Sydney, but still 400 miles south of the Tropic of Capricorn.

Here, again, I sought the botanical gardens, and at once met Mr. F. M. Bailey, the government botanist, author of the Queensland Flora. Although more than eighty years old, he is still at work and was able to describe accurately the habitats of all the Queensland cycads. His

son, Mr. J. F. Bailey, director of the garden, and, like his father, thoroughly acquainted with the Queensland flora, accompanied me on a four days' trip, during which he showed me *Macrozamia Denisoni*, growing on the top of Tambourine Mountain. It is a beautiful cycad, regarded by some as the most beautiful species of the family, and has an immense cone which reaches a weight of seventy pounds.

Although cycads were always dominant in my plans, one of the most delightful and profitable experiences of the whole trip was an excursion to Tabby-Tabby Island. Mr. Bailey had promised to show me the staghorn fern (*Platycerium*) and accordingly went from Tambourine Mountain to Tabby-Tabby, a small island owned by Mr. Wm.

FIG. 5. VIEW IN THE BOTANIC GARDEN AT SYDNEY. The large palm is *Jubea spectabilis*, a native of Chili.

Gibson, who entertained us royally and took us out in his motor boat to the home of the peculiar fern. I had seen fine specimens in greenhouses, but nothing to suggest the wonderful display on the islands about Tabby-Tabby. One specimen was eight feet wide, and specimens four, five and six feet wide were common. It was easy to get a score of ferns on a single photographic plate, and often one could get both species, *Platcerium grande* and *P. alcicorne*, on the same plate. Many of the trees were so loaded that they were leaning, and some had even fallen on account of the great weight of the growing ferns (Fig. 6).

Besides the botanical garden, with its extensive collections, Brisbane has an acclimatization garden, in charge of Mr. Soutter, devoted particularly to experiments in acclimatizing plants, the work being

similar to that conducted by our own Department of Agriculture at Washington.

While Brisbane is a business city, inclined to emphasize the practical side of everything, the fine arts are not entirely ignored. There is a large art gallery, a fine library and museum, and, in the town hall, a splendid organ upon which regular recitals are given, as in Sydney.

Rockhampton, about 400 miles farther north, is situated on the Tropic of Capricorn; its principal newspaper is the *Capricornian.* Here, too, I at once sought the director of the botanical garden, Mr. Simmons, who continued the same generous hospitality and helpfulness which had made previous work so successful. The cycad collection in the garden was not very extensive, probably because cycads are so abundant in this vicinity that it does not seem worth while to bring them in.

Mr. Simmons took me out in a carriage, and within less than an hour's drive, showed me *Cycas* and *Macrozamia* growing together. The owner of the land, Mr. Snell, is related to the Snell who gave Snell Hall to the University of Chicago, and so we were acquainted at once. The study was rapid and satisfactory, for, just to let me see the anatomy of a trunk or structure of a bud, Mr. Snell chopped down plants which would have been the pride of the conservatory in Kew or Berlin.

About 40 miles from Rockhampton, at Maryvale and Byfield, *Bowenia spectabilis* var. *serrulata* is very abundant, forming a dense but easily penetrated undergrowth in the ever-present eucalyptus bush. This small cycad richly deserves its specific name, *spectabilis,* for the leaves are smooth, have a rich dark green color, and retain their beauty for several days after they have been cut off. It seems strange that *Bowenia* is almost never found in greenhouses.

At Springsure, about 200 miles west of Rockhampton, a fine cycad, *Macrozamia Moorei,* is being exterminated because it causes "rickets" in cattle, a disease which usually proves fatal.

Ever since I landed at Sydney, botanists had advised me to visit the Cairns district for a view of genuine tropical vegetation. Although Cairns is 700 miles north of Rockhampton and without any railway connection, it seemed worth while to make the trip by the small coasting boats. In density, the Cairns jungle surpasses anything I had ever seen in the Mexican tropics. The profusion of palms, tree ferns and various vines and epiphytes was bewildering. Along the streams *Angiopteris,* a remarkable fern, small specimens of which are occasionally seen in greenhouses, reaches a tremendous size, with leaves nearly twenty feet long and stalks as large as a man's arm. At Herberton, near Cairns, a beautiful tree fern, *Dicksonia Youngii,* is so abundant that it forms almost impenetrable jungles. Besides, in open places, all three genera of cycads found in Australia may be secured within a single day's tramp.

In this region I had my first view of the Australian bushman, and he is certainly the lowest of all the natives I met during the whole trip. I could admire his boomerang and the way he threw it, and also his almost ape-like agility in climbing trees, but he hardly seems to be reassuring material for civilized citizenship.

Although a year's field study of the cycads about Cairns and north of Cairns would doubtless have proved productive, I had no more time,

Fig. 6. *Platycerium*, the Stag Horn Fern.

and had to hasten to meet my boat sailing from Sydney on December 16, 1911. There are few cycads south of Sydney, and consequently, a steamer stop of three days at Melbourne finished the work in Australia.

Although Melbourne is about 1,500 miles south of the Tropic of Capricorn, the climate is mild, and palms, tree ferns, cycads and araucarias flourish in the botanical gardens. The director, Mr. Cronin, was particularly proud of the tree fern display, which could hardly be

surpassed. For scenic beauty the garden at Melbourne deserves a high rank among the great botanical gardens of the world.

After a long voyage of twenty-six days, we arrived at Durban, the principal port of South East Africa. Here I was the guest of Dr. J. B. McCord, a medical missionary, and a fellow alumnus of Oberlin College, whose knowledge of South Africa, and especially of Zululand, greatly facilitated my investigations.

At the botanical garden I met the director, Dr. J. Medley Wood, now an old man, and Mr. J. Wylie, the curator, who is particularly interested in palms and cycads. Mr. Wylie at once became interested in my work and not only helped me with my study of the cycads at the

FIG. 7. A KRALL IN ZULULAND.

garden, where the collection of *Encephalartos* is the largest and finest in the world, but he accompanied me into the field and sent a Zulu from the garden to be my guide and factotum during my stay in Zululand.

There are only two genera of cycads in Africa, *Encephalartos* and *Stangeria,* and they are found only in South Africa. I found both genera in Zululand and secured an abundance of material for further study.

The Zulus are a superior race, both physically and mentally, thanks to the practical eugenics of the good old days before the English came, when deformed or sickly babies were promptly killed, and thus prevented from propagating their failings.

Fig. 8. *Euphorbia tetragona,* near Cathcart, South Africa.

The young man must work hard to get his first wife, for wives cost about $500 apiece. Then, with a helpmeet, it is easier to get the second wife, and a third wife comes still more easily. There is no reason why a man with three wives should work any more, and so life becomes easy for him. As he gets older, he has daughters to sell, and can buy more wives. The average well-to-do Zulu has from half a dozen to a score of wives and it is not unusual for a chief to have several hundred. A man with only one wife has about the same standing as a slaveholder with only one slave had in the south before the Civil War, and, consequently, the earlier wives are eager to work hard to elevate the standing of the family. The whole family lives together in a collection of huts, called a krall (Fig. 7), each wife having a hut of her own, and the polygamous husband boarding around. You can tell the number of wives in a family by counting the houses in a krall.

At Cedara, a government experiment station about eighty miles northwest of Durban, the extensive work in forestation is interesting from both the botanical and economic standpoints. This work is under the direction of Mr. Stayner, who has received all the training Kew affords. Many believe the extensive grass velts of South Africa were originally covered by forests, and that the native, with his childish desire to see things burn, had destroyed the forests before white people

arrived. At any rate, trees grow rapidly on the velts, especially on the mountain sides, and if the forestation continues, within a short time there will not only be an abundance of lumber, but the climate of the country will be vastly improved.

Stangeria and two species of *Encephalartos* grow in the neighborhood, but are not abundant. There are gorgeous flowers on the grass velts, and in the ravines, or *kloofs,* there are many ferns and lycopodiums.

The next point on my schedule was Queenstown, not very far from Cedara, as the crow flies, but quite remote as South African railways go, through Ladysmith, Bethlehem, Bloomfontein and Springfontein, names made familiar by the Boer war, a country dotted with monuments and cemeteries.

At Queenstown, the president of the bank, Mr. E. E. Galpin, is a fellow of the Linnean Society of London. He kindly arranged for a day's absence from the bank and not only showed me a great display of *Encephalartos Frederici Guilielmi,* a species I had never seen, but gave me valuable information which only a competent observer could give after many years' acquaintance with the locality. Mr. Galpin also facilitated my work at Cathcart and gave me directions for finding *Encephalartos Lehmannii,* which, as yet, I had seen only in gardens. Near the Kei River, where I found this species, *Euphorbia tetragona* is a prominent feature of the landscape, a big tree, reaching a height

FIG. 9. VIEW IN BOTANICAL GARDEN AT PORT ELIZABETH.

of 60 feet (Fig. 8). I am further indebted to Mr. Galpin for an introduction to his brothers, the Galpin Bros., wealthy jewelers and competent amateur botanists, of Grahamstown, who took me in their touring car to all the cycads within easy touring-car reach of the city.

Grahamstown is an educational center, with a good college, a conservatory of music and an excellent museum. Dr. Schönland, the professor of botany in the college, gave me an account of the cycads of the vicinity, including the almost unknown *Encephalartos latifrons*.

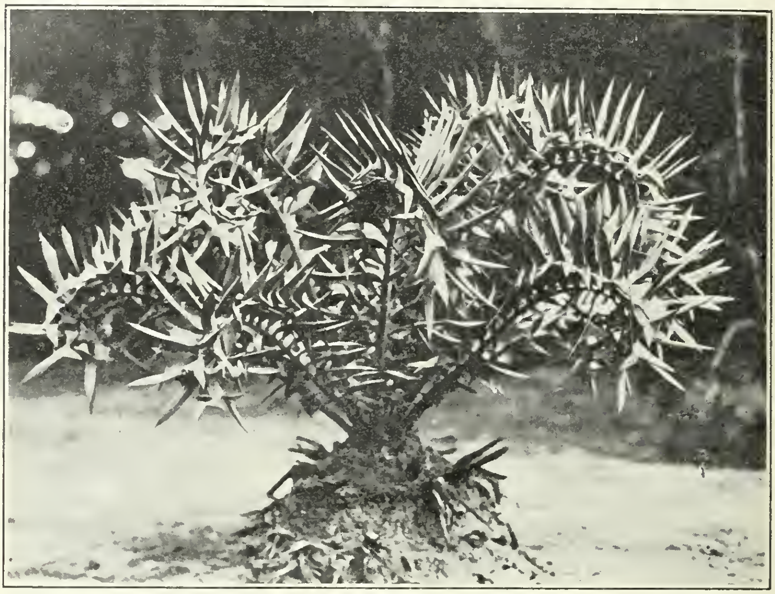


FIG. 10. *Encephalartos horridus* IN ST. GEORGE'S PARK, PORT ELIZABETH.

The botanical garden at Grahamstown maintains the high standing I had learned to expect in the botanical gardens of the English colonies (Fig. 9). The director, Mr. Alexander, gave me some valuable specimens which are now flourishing in the greenhouse at the University of Chicago.

I had two more points, with outlying side trips on my schedule, East London and Port Elizabeth. On the voyage from Vancouver to New Zealand, I mentioned at table to Mr. Vance, who sat beside me, that I could find out but little about these places. Naturally, I was surprised and delighted to find that he had been mayor of East London for years and that his wife knew the cycads of the vicinity and could give me definite directions for finding them.

When I arrived at East London, Professor Rattray, of Selborn College, accompanied me into the field, and although he did not claim to be a botanist at all, showed such an extensive and critical field

knowledge of South African cycads, that I asked him to prepare an article for the *Botanical Gazette*. Other plants of the vicinity were also of interest, but my time was becoming short.

The final point on the schedule, as far as cycads were concerned, was Port Elizabeth, where Mr. Butters, the director of St. George's Park, gave me definite information and accompanied me on the trips into the field. From this place I visited Van Staadens, the type locality of *Encephalartos caffer,* and Despatch, a good locality for *Encephalartos horridus,* a frightful species which holds its place in the conservatory as the gargoyle does in architecture, by its forbidding aspect. With its spiny leaves, as threatening as porcupine quills, it deserves its specific name (Fig. 10). It is a pity that nomenclature should be burdened with names like *Altensteinii, Lehmannii, Frederici Guilielmi, Vroomi* and *Purpusi,* when suggestive names like *spinosus, pungens, sanguineus, ferox* and *tribulosus* are still available; but taxonomists will do it.

The object of the trip was now far more thoroughly accomplished than I had dared to anticipate when I left Chicago, for I had seen all the oriental genera of cycads, and most of the species, growing in the field, and had not only secured notes and material, but had arranged to have plants sent to Chicago and had also arranged to have histological material fixed at short intervals for a year, in order to make sure of a complete study of life histories. Much of this would have been impossible had it not been for the unbounded hospitality which everywhere facilitated the work.

Of the few days at Cape Town, while waiting for the boat, one was spent at Stellenbosch, the Athens of South Africa, one on Table Mountain, one at Glen Cairn, an excellent place for marine algæ, and two or three at the South African College. This college is the hope of higher education in South Africa. Its department of botany includes three botanists of international reputation and doubtless other departments are also of high rank, so that the college deserves to rank with first-class institutions of other countries.

The trip back to Chicago was tedious but comfortable, for I was not troubled by seasickness, only one day out of more than ninety days upon the water being marked against my record.

For one who is only an investigator and not at all adventurous, such a trip can hardly be said to have any dangers, except the usual dangers of the sea and, perhaps, some dangers from snakes in South Africa. Long tramps, hard climbing and some hot weather must be expected, but a man of middle age and in fair health should come back stronger than when he started, and the investigator and teacher is sure to come back with abundant material for his research, his lecture-room and his laboratory.

SOME ASPECTS OF ANAPHYLAXIS

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THE word anaphylaxis is used to designate the train of symptoms and signs which is produced by the incorporation of a foreign soluble proteid into an animal organism which has already been subjected before to the action of this same foreign proteid. The first injection need cause no obvious disturbance at all, and the injected animal seems to be perfectly normal. But if this animal be reinjected after an appropriate interval, it will answer with marked reactions, which may even end in death. Thus, for example, 5 to 6 cubic centimeters of horse serum injected intraperitoneally in a guinea-pig cause no more apparent disturbance than the same quantity of physiological salt solution; but if the same animal receive the same amount of the same horse serum intraperitoneally after two or three weeks, the animal usually dies in a short time. The first injection, therefore, though it caused no obvious change in the animal, has profoundly altered its constitution, and it reacts on second injection as if the original substance were now a violent poison. The animal, however, does not acquire this remarkable property at once; approximately ten to fourteen days must elapse before the second injection elicits marked toxic effects. If the injection is repeated earlier, slight or no symptoms will be produced. It is thus clear that the organism requires a certain length of time before the second injection can call forth toxic symptoms. The whole process, then, shows three distinct phases:

(1) *Sensitization,* caused by the first injection of the foreign proteid; (2) *Incubation,* the time which elapses before the second injection can cause a response; and (3) the state of *Intoxication* which this second injection causes when given to a sensitized animal.

These three stages show some interesting points which deserve to be mentioned more in detail.

Sensitization.—Any soluble proteid may be used to sensitize an animal, provided that it is of foreign nature; nor need these proteids be of animal origin; Wells has recently shown that a large number of plant proteins may be used for this purpose.

The proteid usually employed in laboratory investigation, for anaphylaxis can only be studied by animal experiment, is horse serum, and horse serum is used only because it is easily obtainable, and is not poisonous to the ordinary laboratory animals on first injection. A

normal guinea-pig will easily tolerate five, a rabbit twenty and a dog one hundred cubic centimeters intravenously, without showing any obvious effect on blood-pressure or respiration. Harmlessness on first injection is, however, not an absolute essential, and animals may easily be sensitized by primarily toxic sera or poisonous animal extracts, for the amount needed to sensitize is very slight, and is only a small fraction of the lethal dose.

The amount necessary to sensitize is almost unbelievably minute; according to Rosenau and Anderson, 0.000,001 cubic centimeters of horse serum may suffice for a guinea-pig, and Wells has succeeded in sensitizing the same animal species with a still smaller quantity of pure egg albumen, 0.000,000,05 gram. These quantities are beyond the capacity of any balance or test tube to detect, and the biological reaction, as usual, is shown to be the most delicate.

The substance used for sensitization may be incorporated in a variety of ways: by subcutaneous, peritoneal or intravenous injection. Even by feeding the proteid, sensitization may be produced in the guinea-pig according to Rosenau and Anderson. The usual method employed, however, is either subcutaneous or intraperitoneal injection; both these procedures are swiftly and easily carried out, and give but slight or no discomfort to the animal.

Although not every species of animal has been tested, it seems probable that all may be sensitized. The only difference noted is that some species are more difficult to sensitize than others; the guinea-pig is most easily sensitized of all animals tested so far, and for this reason has been the classical animal for investigation. The dog and the rabbit are also rendered hypersusceptible with comparative ease. Fowl are more refractory; man also can be sensitized.

The length of time that sensitization lasts varies in the different animal species. In the guinea-pig that state persists for life, which is about three years (Rosenau and Anderson). In the rabbit the degree of sensitization diminishes after three or four weeks, but persists to a greater or less extent for many months, and in man symptoms have been noted seven years after the first injection.

The degree of sensitization varies also in the different animals and will be considered more fully later.

Incubation.—After the animal has received an unaltered foreign proteid into its circulating juices, this foreign material causes a profound change in the reactions of the host to this proteid. This change occurs gradually and reaches its maximum only after some weeks. If the animal is tested after a few days no reaction will be obtained. In guinea-pigs, for example, ten to fourteen days must elapse before an anaphylactic response can be expected with some certainty, and even with these animals it is best to allow three weeks to pass before testing.

The period of incubation, however, may be shortened if an animal is rendered *passively anaphylactic*. This process depends upon the fundamental observation of Gay and Southard that a normal guinea-pig may be sensitized by injecting it with the serum of another guinea-pig which is already sensitized. If a normal guinea-pig is thus injected with the serum of an animal (guinea-pig, or rabbit more usually) which was sensitized some weeks previously, this normal guinea-pig becomes fully sensitized within twenty-four hours and will respond with typical symptoms when injected with the same proteid which was used to sensitize the donor of the serum (Otto). The serum of an actively sensitized animal, that is, one sensitized by the injection of a foreign proteid, therefore contains some substance, termed a serum-rest or anaphylactin by Gay and Southard, which upon injection fully sensitizes a normal animal within a few hours.

Intoxication.—In this stage we observe how a sensitized animal responds with violent symptoms to an injection of the same proteid which it formerly tolerated with no apparent ill effect; we see the remarkable transformation of what formerly was an apparently harmless substance into a violent poison. The symptoms and signs noticeable in an animal during this stage vary with the species and with the site of injection of the toxic dose. If the injection is given subcutaneously in rabbits, an area of edema develops in the place injected; this edema may gradually lead to a circumscribed necrosis of the skin (phenomenon of Arthus). The same change may also occur in guinea-pigs, as Lewis has shown. If the second injection is given intravenously in rabbits, a more or less marked respiratory disturbance associated with muscular weakness and increased peristalsis develops (Arthus); if the rabbits are highly sensitized, convulsions followed by death occur in a few minutes (Arthus). In the dog, the respiratory symptoms are not prominent, but the animal shows nausea and vomiting, profound muscular weakness and often discharge of urine and feces. The animals, however, usually recover. In the guinea-pig, the stage of intoxication is dominated by respiratory symptoms. The animal makes such powerful respiratory attempts that the costal arch is drawn inwards with each inspiration; these efforts swiftly become convulsive and the animal dies a few minutes after the intravenous injection of an adequate dose (Auer and Lewis).

Anatomical and Functional Changes Found in the Stage of Intoxication.—The study of anaphylaxis from the clinical symptoms alone is unsatisfactory. The symptoms offer nothing which could not be produced by numerous drugs available to the investigator; they do not indicate *why* the animal shows these disturbances. For an adequate picture of the process the seat of these reactions and a finer analysis of the functional disturbances is necessary. Moreover, no rational thera-

peutic intervention is possible if the investigator is in the dark concerning these points. The first attempt to study anaphylaxis more thoroughly was made by Arthus in 1903. This investigator showed for the first time that anaphylaxis in rabbits is characterized by a marked drop in blood pressure. This drop in blood pressure Arthus considers the most delicate indicator of anaphylaxis. In 1910 Cesaris-Demel described the effects which were produced when the *excised* heart of a sensitized rabbit was perfused with a dilute solution of the same proteid which caused sensitization. He stated that such a heart rapidly decreased the amplitude of its beat and assumed a condition of greater tonus; toxic effects were also noted on normal hearts, but by no means as pronounced as in sensitized hearts. In 1911 Auer showed independently that the heart of an intact anaphylactic rabbit of sufficiently high sensitization rapidly fails to do its work, and that the animal succumbs for this reason. The functional basis for this heart failure was shown to be a complete or almost complete loss of direct irritability of the heart ventricles. On macroscopical examination of the heart muscle, the right ventricle shows a toughening of the muscle bands on its endocardial surface when scraped by the finger nail. The left ventricle does not show this toughening, except now and then on its papillary muscles. The same observer also demonstrated that these cardiac changes were obtained after section of the vagi, and after destruction of the central nervous system, thus proving that the fatal cardiac reaction was not due to central, nervous influences, but was of peripheral origin. He also noted the absence of any marked disturbance of the lungs in anaphylactic rabbits.

In dogs, Biedl and Kraus, and later Arthus, proved that the main symptom of anaphylaxis was a rapid, profound and long-lasting drop in blood pressure. Experimental evidence led Biedl and Kraus to the view that this fall was due to a paralysis of the vasomotor endings in the splanchnic area. Associated with this drop in blood pressure the same observers noted a diminution in the number of leucocytes, and an extreme loss of coagulability of the blood. Blood drawn from a dog during the anaphylactic state remained fluid for many hours, sometimes days. The respiratory function showed no noteworthy alterations. The dogs recovered as a rule.

The functional alterations produced by anaphylaxis in guinea-pigs is entirely different from those observed in rabbits and dogs. In the guinea-pig, Auer and Lewis showed that the functional interference occurs in the lungs. Within a few seconds after the intravenous injection of an adequate "second" dose the animal shows greater and greater difficulty in getting air into and out of its lungs, until finally a stage is reached where no air at all enters on inspiration and this in spite of the fact that the animal makes most violent inspiratory attempts. Three

to five minutes after the injection respiration ceases and the animal dies of asphyxia. The heart keeps on beating for many minutes after all respiration has stopped. Inspection of the lungs shows a remarkable picture; on opening the thorax, the lungs do not collapse as normal lungs do, but remain fully distended and form a cast of the thoracic cavity (see Fig. 1). Their color is pale bluish pink and the lungs are light in weight. The same lung picture was obtained with equal promptness when the vagi were cut or when the central nervous system was destroyed, thus demonstrating that this lung condition was of peripheral origin and independent of the central nervous system for its production. On the basis of experimental evidence which need not be detailed here, Auer and Lewis conclude that this striking lung condition is produced by a tetanic contraction of the muscles in the finer bronchial tubes. On the basis of this, atropin was used prophylactically with good results, 72 per cent. of the treated animals recovered, while 75 per cent. of their untreated mates succumbed (Fig. 1). The blood-pressure curve in these fatal cases does not resemble that seen in dogs, nor does the blood show a strongly increased coagulation time.

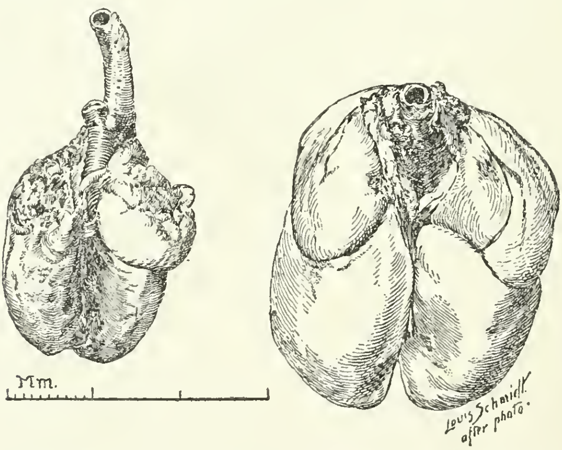

FIG. 1. The large inflated lungs were obtained from a typical fatal case of horse-serum anaphylaxis in a guinea pig. The small collapsed lungs belonged to an anaphylactic guinea pig of the same lot which was saved by the injection of atropin. This animal seemed normal when killed. The picture shows strikingly the characteristic lung picture of anaphylaxis and the remedial effects of atropin.

The right vagus nerve had been resected in each guinea pig thirteen days before the toxic injection.

It will be observed that the important functional disturbances differ in the three species of animals which have been considered above: in the *dog,* the main noticeable effect is a profound, lasting drop in blood pressure associated with a great increase in the time necessary to cause coagulation; the lungs show no lasting inflation. In the *rabbit,* the heart stops beating and the cardiac muscle exhibits a total or almost

total loss of direct irritability to mechanical and electrical stimuli; the lungs show areas of emphysema, but collapse more or less completely when the thorax is opened; the blood shows delayed coagulability, but by no means as great as that observed in a dog. The fall in blood pressure is probably secondary to the failure of the heart. In the *guinea-pig,* the lungs are the chief organs affected and their function is abolished by a stenosis of the finer air passages preventing in the final stage both the entrance and exit of air, so that death results from asphyxia. The anatomical sign of this condition is furnished by the large inflated lungs which do not collapse on excision from the chest cavity (Fig. 1). The heart keeps on beating after final respiratory stoppage, with no obvious loss of irritability; the blood shows only a slight delay in coagulation and the fall in blood pressure is probably due to the fatal asphyxia. These differences between the three species of animals show clearly the necessity of judging each species by the anaphylactic signs characteristic for it and not by manifestations only found in another species. This important point, that each animal species must be measured by its own yard-stick when examined in anaphylaxis, has not been realized, unfortunately, by some investigators.

Causation of Anaphylaxis.—The remarkable phenomena which characterize anaphylaxis early led investigators to search for the causative agent. Numerous theories, more or less supported by experimental facts, were advanced to explain how, for example, the originally harmless horse serum becomes toxic when injected into an animal sensitized by this substance. The pioneer work of Vaughan, Friedemann and Friedberger deals particularly with this aspect of anaphylaxis. A discussion of all the theories here, however, would lead too far and would only befog the reader. It will suffice to state that the basic idea of the chief theory is that the sensitized organism has acquired the power to split the alien serum very rapidly into its components when injected for the second time, and that these components then act as a poison. There can be no theoretical objection to this conception; it is a legitimate working hypothesis. But there are weighty objections just as soon as one substance or mixture of substance is produced from proteids in the test tube by chemical or biological processes and considered as the causative agents of anaphylaxis because when injected into normal animals they produce more or less completely the signs and symptoms which are characteristic of true anaphylaxis. The assumption *may* be true, but no rigid proof has so far been advanced that these substances really are produced in the animal body during anaphylaxis. The mere fact that these toxic substances produce a lesion which also occurs in true anaphylaxis, by no means justifies the conclusion that the causative agents were the same in the two processes. Take, for example, the pale, rigid, distended lungs produced in a sensitized guinea-

pig which succumbs acutely to an intravenous injection of horse serum, and which are diagnostic, when properly considered, of true anaphylaxis in this animal. These lungs owe their state to a tetanic contraction of the bronchial muscles, so that the enclosed air is imprisoned in the alveolar sacs and can not escape even when the lungs are completely excised (see Fig. 1). Now, any adequate stimulus which causes an enduring contraction of these muscles while respiration goes on will produce a greater or less approximation to the lung picture of anaphylaxis. Such adequate stimuli are furnished by a large number of substances, of which we may mention muscarine, eserine, pilocarpine, digitaline, veratrine, morphine barium chloride and the salts of many heavy metals (Dixon and Brodie). Nobody, however, would state that the substances cause anaphylaxis, that they are anaphylatoxins, even though they do produce apparently a lesion of anaphylaxis, for it is perfectly obvious to every one that it is inadmissible to conclude from the identity of reaction produced (in the example chosen, the anaphylactic lung) an identity of the causative agents, as this leads to the ridiculous conclusion that eserine, muscarine, etc., are identical. The same reasoning is applicable to the degradation products obtained by chemical or biological means from proteids. It is not surprising that decomposition products of the infinitely complex proteid molecule should yield substances which are toxic to an organism, and which produce anatomical and functional changes similar to those observed in anaphylaxis, but this does not permit the conclusion that the same decomposition products are formed and exert their actions in true anaphylaxis; such reasoning commits the same error which was mentioned before. It must be insisted that an identity in the biological response caused by a variety of substances permits only the conclusion that these substances are *functionally* identical, not that they are chemically or so to say, morphologically identical. This confusion is widespread, and at present dominant; it is especially due to the *per se* valuable and interesting contributions of Friedberger and his colaborers. Friedberger is convinced that the poisonous mixture which he produces by biological methods in vitro is identical with the causative agent or agents in true anaphylaxis, and in most of his recent work the symptom complexes studied were not true anaphylaxis, but the symptoms produced on first injection by his anaphylatoxin.

The question has probably occurred to the reader why this problem was not approached directly, why, for example, the serum of animals in anaphylaxis was not examined for the presence of these degradation products which are said to play such an important rôle. The test can easily be made, for the split products of proteids which have an albumose or pepton character give the biuret reaction. But no investigator, as far as I am aware, has been able to obtain more than a very feeble or

no reaction from the serum of an animal dead from true anaphylaxis, provided that the test was carried out after the total removal of all coagulable proteids, thus leaving the non-coagulable peptones and albumoses in the filtrate. This method, therefore, gives no evidence of any degradation product demonstrable by the biuret reaction (Pfeiffer and Mita).

The question was attacked in still another fashion by Abderhalden and Pincussohn. If the intoxication of anaphylaxis is produced by the rapid production of toxic cleavage products from the injected proteid, it is legitimate to assume that the serum of sensitized animals should possess ferments which rapidly accomplish this degradation of the proteid molecule. The experimental test was successful in demonstrating proteolytic ferments, but these ferments were not specific nor of very active nature; and later work by Gruber renders their relation to anaphylaxis quite doubtful.

Summing up the evidence which we have regarding the identity of proteid cleavage products and the causative agent or agents of true anaphylaxis, it must be said that while the assumption is theoretically tenable, a firm experimental basis for this assumption is yet to be laid. Moreover, investigators who unreservedly identify the disturbances caused by proteid constituents produced in vitro, with true anaphylaxis, are causing confusion in another direction. Not only is a perfectly well defined symptom-complex like anaphylaxis obscured by this extension of its scope, but a number of characteristic signs of anaphylaxis lose their significance. Before this can be discussed profitably, the original meaning of the word anaphylaxis as well as the functional disturbances and anatomical signs which characterize it, must clearly be kept in mind. On account of the importance of this, it may perhaps be permissible to give a short résumé of matter already discussed.

Meaning of the Word Anaphylaxis, and Diagnostic Criteria.—What the word anaphylaxis was coined to indicate has already been stated; it means the symptoms and signs which are produced when an organism is resubjected to the action of a foreign soluble proteid. When horse serum, for example, is employed, the first injection causes no untoward effects; the second injection, however, gives outspoken and pronounced results which did not occur after the first injection, and these effects are only obtained when a proper interval has elapsed between the two administrations of horse serum. In active anaphylaxis there are three well-defined stages—sensitization, incubation and intoxication. In passive anaphylaxis, where a *normal* animal is sensitized by the injection of the serum of a *sensitized* animal, the same three stages are present, but the period of incubation is now shortened to a few hours. If, therefore, reactions are obtained in an animal after the second or so-called toxic injection which were absent when the first one was given,

we are justified in speaking of the response as an undoubted reaction of anaphylaxis. The three conditions necessary for the employment of this word are fulfilled, and we are dealing with the same phenomena or group of phenomena which the older observers noted and which they called hypersensitiveness, Theobald Smith's phenomenon or anaphylaxis. If these considerations are followed a field of investigation with sharply defined borders is opened up, and every observer is enabled to judge whether or not his particular patch lies within this territory.

These criteria yield a sharply circumscribed mass of phenomena which are undoubtedly caused by the same general process, and which may now be further analyzed without any doubt, whether or not they are of anaphylactic origin. The more obvious signs and symptoms have already been established in dog, guinea-pig and rabbit, which are the animals usually employed in laboratory investigation. But it must be continually borne in mind that the characteristic anaphylactic responses of these three species are characteristic only when they are obtained after the second injection of a soluble proteid; the profound drop in blood pressure in the dog, the large immobilized pale lungs in the guinea-pig and the loss of irritability and contractility of the heart muscle in the rabbit, do not occur when a harmless soluble proteid like horse serum is injected for the first time; they only appear when the injection is repeated after the period of incubation, and this peculiarity characterizes them as anaphylactic and differentiates them at the same time from similar reactions which occur on first injection of a large number of substances.

These considerations render clear, perhaps, why it is not justified at present to admit that those cleavage products of proteids which cause a similar disturbance on first injection really produce true anaphylaxis, for as soon as this assumption is granted the three characteristic conditions of anaphylaxis which give this symptom complex an independent existence by delimiting it from similar complexes, is obliterated. Moreover, the clean and outspoken functional responses found in the three animal species in anaphylaxis lose their diagnostic character and independence, and fall back into the ruck, indistinguishable from a mass of similar reactions. This is surely a heavy price to pay for an extension of the meaning of anaphylaxis, especially as this extension is not necessary. Even when true anaphylatoxins are isolated, no such broadening of the term will be necessary, for only those substances can be considered true anaphylatoxins which are isolated biologically from the tissues and circulatory juices of a case of true anaphylaxis; and these substances must practically not be present in normal animals, but when injected into these normal animals the anaphylactic symptoms and signs characteristic for the species employed must be obtained. Such substances may be the product of proteid cleavage, but they will bear

the name of anaphylatoxins legitimately, for there is no cloud regarding their origin. Such substances, with such a pedigree, have not been isolated so far. With these properly identified anaphylatoxins no confusion will be produced, for they will cause a true anaphylaxis, and the usual conception of this process will not be obscured, but, on the contrary, clarified.

This question of the causal relationship between proteid cleavage products obtained in vitro, and the symptoms and signs of true anaphylaxis has been discussed at some length because this view-point of the problem enjoys great favor; because it was necessary to point out that this view as formulated at present leads to confusion, to the useless sacrifice of a well-defined symptom complex and its characteristic anatomical and functional signs, and finally because this view is not the necessary and inevitable consequence of the experimental data at hand.

Other Manifestations of Anaphylaxis. Serum Disease.—The description given so far has dealt exclusively with the experimental analysis of the more important anaphylactic phenomena in lower animals. But similar phenomena occur in man and these have been extensively studied. Opportunity for this study was afforded shortly after therapeutic sera were generally employed to combat disease, especially diphtheria.[2] To v. Pirquet, associated in his earlier work with Schick, we owe the most thorough study of some of the reactions which the human organism may show when injected with various kinds of therapeutic sera. These reactions v. Pirquet and Schick called serum-disease. The development and course of this serum disease is as follows. The *first* injection of a therapeutic serum, usually obtained from an immunized horse, is tolerated by most individuals without any reaction. In those that do react, the symptoms do not develop at once, but after the lapse of eight to ten days. The chief disturbances which now occur are fever, skin eruptions, swelling of the lymph glands near the site of injection, pains in the joints and muscles and edema of the face and dependent portions of the body. In spite of this apparently formidable list of ailments the general condition of the patient is excellent, as a rule, and there is but slight danger.

When the same patient is reinjected after an interval of more than ten days, the picture is somewhat different. The period of incubation is practically absent or at least considerably shortened, and the symp-

[2] It must be stated at once that these undesirable accessory reactions which sera sometimes show in the human being form no contraindication to their employment in proper cases. In severe diphtheria, for example, the antidiphtheritic serum is the only remedy which can save the patient from death; to hesitate in its employment because it may produce more or less severe symptoms itself, would be criminal, as this action might be equivalent to throwing away the only chance of recovery the patient has.

toms either develop after a few hours, the "immediate reaction," or after a few days, the "accelerated reaction." As the time interval between the injections increases the "immediate reaction" no longer appears, but the "accelerated reaction" still occurs and has even been noted when the second injection followed seven years after the first. The symptoms which characterized the "accelerated" reaction are similar to those already described, with this difference that they occur suddenly, and disappear swiftly within approximately a day. The "immediate" reaction is somewhat different and characterized by a local edema at the site of injection which slowly increases and reaches its maximum within about twenty-four hours, and disappears within two to five days. Associated with this local reaction there is high fever, and the skin shows crops of transitory eruptions of varying character. In a small proportion of all cases the immediate reaction shows a grave picture, there is nausea and vomiting, and at times even collapse.

The similarity between serum disease and anaphylaxis was early noted by v. Pirquet and Schick. The specific local edema, for example, is exactly analogous to Arthus's phenomenon in rabbits; the non-fatal collapse cases also are similar to the results which Arthus obtained in rabbits where he noted a strong drop in blood pressure.

There is another class of severe reactions, fortunately rare, which occur suddenly when a patient is injected for the *first* time with serum. The symptoms bear a striking analogy to those observable in lethal anaphylaxis in guinea-pigs and rabbits. Some individuals show a marked respiratory distress of an asthmatic type with cyanosis, similar to guinea-pigs, and others again show symptoms where the respiratory involvement is not so pronounced, but where cardiac weakness predominates. These cases often end in death. Examination of the history of such individuals often shows that they were subject to asthma, or possessed a peculiar idiosyncrasy to the odor of horses which brought on the symptoms of hayfever and asthma. Cases of this kind are probably examples of anaphylaxis in spite of the apparent absence of any sensitizing injection, for this state of sensitization could easily be attributed to inheritance or to a gradual sensitization via the lungs or the stomach. It is well-known, for example, that a sensitized guinea-pig will transmit this property to her offspring, and we may assume that this also plays some rôle in human cases; moreover Rosenau and Anderson have shown that sensitization may be accomplished in guinea-pigs by feeding raw horsemeat, and more recently Rosenau and Amoss reported that they were able to sensitize guinea-pigs for human serum by injecting the infinitesimal amount of organic material found in the expired breath of human beings. These experimental facts render it quite probable that all these cases where the first injection of horse serum produced alarming symptoms or even death, were sensitized in

one of the ways mentioned to this proteid. It is interesting that those individuals which recover are in a state of anti-anaphylaxis for some time afterwards, that is, they are temporarily free from attacks of asthma or hayfever, from which they suffered before.

Local Reactions of Anaphylaxis.—In 1890 Robert Koch announced that the injection of tuberculin produced a local and general reaction in tuberculous guinea-pigs, which, he said, led to an arrest of the tuberculous process and even to health. Everbody probably remembers the sensation which this statement caused. Unhappily, however, the results obtained later in clinical tests did not fulfil expectations. Nevertheless, one important fact remained: the important diagnostic value of the febrile reaction which follows the injection of tuberculin in the tuberculous individual. This reaction occurs only in subjects which are tuberculous, in other words in those who are sensitized by the proteids of the tubercle bacillus; the reaction is thus one of anaphylaxis.

The original method of injecting tuberculin was not devoid of danger, nor was it at best very agreeable to the individual with a positive reaction. In 1907 v. Pirquet described a cutaneous reaction in tuberculosis which gives accurate results and is devoid of any danger or marked discomfort to the patient. v. Pirquet noted that a very small quantity of tuberculin applied to a local scarification of the skin produced within forty-eight hours a well-marked inflammatory reaction in tuberculous subjects, which did not appear in normal individuals. This inflammatory reaction in an individual shows that he must have been sensitized by the tubercle bacillus, in other words that a tuberculous process is in existence somewhere in the organism. The value of this fact is obvious, for it gives a warning, which if properly heeded may prevent invalidism and death.

A reaction similar to that just described is the ophthalmo-reaction of Wolff-Eisner and of Calmette. Instead of letting absorption take place from the skin these investigators instilled the tuberculin in the conjunctival sac of the eye. In tuberculous subjects a quite violent reaction follows; because of this violent response the ophthalmo-reaction has fallen into disrepute.

Phenomenon of Arthus.—The appearance of a local, massive edema and even necrosis at the site of an injection of serum in a sensitized rabbit was first noted by Arthus in 1903 and has been described before in these pages. In was the first example of a definitely recognized, experimental, local anaphylaxis.

Hayfever.—The most annoying and widespread manifestation of local anaphylaxis is hayfever. Many thousands of people suffer from it in the United States alone. In this country we have two disease periods, the so-called "spring or June cold" prevailing in June and July, and the "autumn catarrh" which begins at the end of July and lasts to October. The majority of hayfever patients suffer during the

latter period, and it is quite exceptional that one individual is afflicted during both periods.

The first attack usually begins near the age of puberty and then recurs every year with such regularity that patients are able to forecast quite accurately the date of their coming illness. The duration of the sickness is approximately six weeks.

The symptoms are those of a catarrhal condition of the mucous membrane of the eyes, nose, pharynx and often of the trachea and bronchi. After a preliminary period of one to two weeks, during which there is a moderate irritation of the eyes and nose, associated with a slight discharge, the disease may reach its maximum within a few days or even hours. At this time the eyes are reddened and swollen, and tear secretion is abundant; the nasal mucous membranes are swollen and injected, causing a copious, watery discharge. In addition there are violent, explosive fits of sneezing together with an intolerable itching, and later a soreness of the nose and the eyes. Subsequently nasal breathing becomes impossible and mouth breathing is necessary. Then irritation symptoms of the larynx, trachea and bronchi develop as shown by attacks of coughing. The lung symptoms vary between a mild bronchitis and a severe asthma.

All these symptoms which make life a burden to the hayfever sufferer are caused by the inhalation of certain pollens. As early as 1831 Elliotson advanced this opinion, and later experimental researches by Blackley and especially by Dunbar placed the theory on a safe footing. Dunbar proved that the albumen fraction of certain pollens was the toxic agent by injecting or instilling this substance in predisposed individuals; under proper conditions the typical symptoms were always obtained. The reaction was specific; thus autumn catarrh patients responded typically to the proteids obtained from ragweed and golden-rod, but showed no effect when the pollen proteid of graminaceous plants was used.

Hayfever patients therefore have acquired in some fashion or another a hypersentiveness to the albumin constituent of certain pollens. When plants bearing these pollens are in bloom, the pollen is distributed by the wind, and when inhaled by susceptible individuals, the typical consequences follow. The specificity of the sensitization explains why some suffer in the spring, when pollen from the flowering grasses is in the air, while others suffer in autumn when golden-rod and ragweed distribute their pollen.

Dunbar has produced a therapeutic serum by inoculating horses with the chief pollen proteids which come into consideration. This pollantin has yielded good results when used prophylactically.

Drug Idiosyncrasies.—There are numerous individuals who react with more or less severe symptoms to drugs which cause no obvious effects in the large majority of people. Among these drugs morphine,

quinine, antipyrine and the iodides may be mentioned. While the history of these cases shows a marked resemblance to anaphylaxis, there is, for most of them, no very definite experimental basis. Friedberger has recently obtained anaphylactic symptoms in guinea-pigs sensitized with an iodine-proteid compound. It would be of theoretical importance if true anaphylaxis could be experimentally produced with these substances, because they are of a non-proteid nature.

Food Idiosyncrasies.—Probably everybody is familiar with the fact that certain foods, harmless for most people, cause marked trouble in others. Certain individuals, for example, react to the ingestion of strawberries, buckwheat, clams, eggs, etc., as if a poison had been swallowed. These cases also are probably anaphylactic, but here again the experimental test is lacking to clinch the relationship between these phenomena.

Treatment of Anaphylaxis.—The treatment is not yet in a satisfactory state, but there are a number of remedies available for some of the manifestations of this protean complex. If an injection of horse serum produces respiratory symptoms of an asthmatic type in a patient, the only rational treatment is the administration of atropin, for the investigations of Auer and Lewis have shown that this asthma is due to a tetanic contraction of the finer bronchioles which hinders or prevents the entrance and exit of air in the lungs, and atropin causes a relaxation of these muscles. In a study of the prophylactic value of atropin injections in guinea-pigs, Auer was able to save 72 per cent. of his animals, while 75 per cent. of the untreated controls promptly died. These results have been corroborated by a number of observers, especially by Biedl and Kraus. The negative results which Friedberger and Mita obtained are probably due to the inadequate dose of the atropin which they administered.

If the injection of the serum, however, causes symptoms of cardiac failure with slight symptoms of asthma, there is no treatment founded on experiment. The treatment must be symptomatic only; but one class of drugs must be avoided. Auer has shown in highly sensitized rabbits that drugs of the digitalis group should not be used, because they hasten the fatal outcome by aiding the production of the same cardiac lesion which anaphylaxis itself calls forth. Moreover, the same observer has recently described changes in the cardiac muscle produced by members of the digitalis group, especially strophanthin, which are very similar to those produced in cardiac anaphylaxis. It is, therefore, clear why these cardiac stimulants must not be given, even though the weak heart would seem to demand their exhibition.

The most rational treatment is the preventive one. The utmost precaution should be observed whenever it become necessary to inject a therapeutic serum in a patient who has been injected with serum before, who is subject to asthma, hayfever, or who shows an idiosyncrasy to

horses. The best treatment of this kind, in my opinion, is the vaccination procedure of Besredka. In this method a very small quantity of horse serum is given subcutaneously or even rectally and time allowed for its absorption. The amount absorbed at any time will be too small to cause serious symptoms and yet enough to produce anti-anaphylaxis. After anti-anaphylaxis has been established, and this occurs quite rapidly, the full dose may be given subcutaneously with some safety. The only objection to this procedure is that time, an hour or two, is lost. The time could be shortened probably, though at some risk. Besredka has obtained good results with the method in guinea-pigs, and it should receive a full clinical trial.

Friedberger and Mita have recently described another method by means of which they were able to protect guinea-pigs against ten times the fatal dose. This result was obtained by a slow intravenous infusion of serum so that only traces enter the circulation at one time. The time of infusion lasted fifty to sixty minutes in their experiments. It will be observed that the same principle used by Besredka, the production of anti-anaphylaxis, is here also utilized.

The treatment for hayfever has already been mentioned.

Importance of Anaphylaxis.—The phenomena of anaphylaxis which have been briefly discussed in the preceding pages are important because they have given us a deeper insight into certain interesting diseases, the so-called idiosyncrasies or predispositions whose causation was formerly inexplicable. The remarkable fact is now established that an organism may be so altered by the injection of an apparently perfectly harmless proteid, that a subsequent injection of the same proteid acts like a violent poison. Predisposition of an individual to any substance means now that this individual is sensitized to this substance. How this sensitization has been accomplished is still undecided in many instances, but the basic conceptions of anaphylaxis will be a safe guide in solving the problem.

It must be emphatically pointed out that the analysis of anaphylactic phenomena would have been impossible without animal experimentation; the chief advances have been made by the functional investigation of these disturbances in laboratory animals and not by tissue examination after death. Thus the autopsies of those early unfortunate cases where death resulted from the administration of a therapeutic serum, yielded no information whatsoever regarding the cause of exitus. The physicians stood before a riddle, the more terrible because its nature was unknown. Animal experimentation has explained this fatal enigma, partially at least, and the physician no longer stands in helpless ignorance before it. He knows the state now, and some methods to prevent or reduce its dangers have been placed at his disposal which promise a fair success.

THE PERMANENCE OF INTERESTS AND THEIR RELATION TO ABILITIES

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THERE is a wide range of opinion amongst both theorists and practitioners with respect to the importance of the interests of children and young people. These early likes and dislikes, attractions and repulsions, are, by some, taken to be prime symptoms of what is for the welfare of the individual or even of the species. By others they are discarded as trivial, fickle, products of more or less adventitious circumstances, meaning little or nothing for the nature or welfare of any one. It seems, therefore, desirable to report whatever impersonal estimates of the significance and value of interests one can secure.

I have measured the significance of interests in certain limited particulars, with very definite results, and shall, in this article, describe these results and the method by which they were obtained and by which any one can readily verify them.

The particular problems attacked all concerned the *relative* amount or *relative* intensity or *relative* strength of interests *within the same individual.* That is, "greater interest" will always mean the interest which was greater than the others possessed by the same individual. Little interest will mean little in comparison with the individual's other interests. The question, "To what extent is the strength of an interest from ten to fourteen prophetic of the strength which that interest will manifest in adult life?" will mean, "To what extent will it in adult life keep the same place in an order of the individual's interests which it had in the order which described his childish preferences?" Amounts or degrees of ability or capacity will similarly always mean *relative* amounts. Thus, to say that a person was, during high school, most interested in mathematics and most able at mathematics will mean that the person liked mathematics more than *he* did anything else, and did better at mathematics than *he* did at anything else. The statement will not imply anything about the degree of his interest or ability in comparison with other individuals.

The particular problems attacked are limited further to seven varieties of interests and the corresponding varieties of ability or capacity, namely, mathematics, history, literature, science, music, drawing, and other hand-work (this last being defined as "carpentering, sewing,

gardening, cooking, carving, etc."). All comparisons or relations of interests and abilities are within this group, so that, for example, the statement that John Doe had interests in the high-school period distributed in the same order of strength as in the elementary-school period will mean that these seven interests had the same order in the two periods.

Such being the meanings of terms and the limitations of the field of inquiry I have measured:

1. The permanence of interests from the last three years of the elementary-school period to the junior year of college or professional school.

2. The correlation or correspondence between interests in a given subject and ability therein at the elementary-school period.

3. The same relation at the high-school period.

4. The same relation toward the end of the college or professional course.

5. The same relation on the whole (this will be explained later).

6. The correlation or correspondence between *interest* in a given subject at the end of the *elementary-school* period (during its last three years) and *ability* in that subject toward the end of the *college* or professional-school period.

The results to be here reported are for one hundred individuals, juniors in Barnard College, Columbia College and Teachers College. These results are corroborated by a similar but less minute study of two hundred other individuals.

The original measures are the judgments of the hundred individuals themselves concerning the order of their interests in mathematics, history, literature and the rest, at each of the three periods. Each individual reported in writing in response to the following instructions:

Experiment 34. (Table 1)

Consider your interests in the activities listed below during the last three years of your attendance at the elementary school. Mark (under El. Interest) with a 1 the activity which at that period was to you the most interesting of the seven listed. Mark the one that was next most interesting, 2; and so on.

Record similarly (under H. S. Interest) the order of interest for you during the high school period. Record similarly (under Col. Interest) the order of interest for you now.

Pay no attention at present to the spaces under ability.

Later he reported similarly his judgment as to his relative ability in each of these seven lines of activity in response to the following instructions:

TABLE 1

	In Last Three Years of Elementary School		In High School		In College	
	El. Interest	El. Ability	H. S. Interest	H. S. Ability	C. Interest	C. Ability
Mathematics........						
History...........						
Literature..........						
Science............						
Music..............						
Drawing...........						
Other hand work[1]....						

EXPERIMENT 35

Consider your ability in each of the activities listed in Table 1, as it existed during the last three years of your attendance on the elementary school. Rank the activities from 1 to 7 according to your ability in each, marking that activity in which you had most ability 1. Record your ranks under the column headed El. Ability in Table 1. Record similarly (under H. S. Ability) the order of ability for you during the H. S. period. Record similarly (under C. Ability) the order of ability for you now.

We have then for each of the hundred a record such as is shown in the case of one of them in Table 2. These data are obviously subject to

TABLE 2

	In Last Three Years of Elementary School		In High School		In College	
	El. Interest	El. Ability	H. S. Interest	H. S. Ability	C. Interest	C. Ability
Mathematics........	3	3	3	2	4	2
History...........	1	1	4	3	1	1
Literature..........	2	2	2	1	2	3
Science............	4	4	1	4	3	4
Music..............	5	5	7	5	5	7
Drawing...........	6	6	5	7	6	5
Other hand-work	7	7	6	6	7	6

certain errors of memory, prejudice, carelessness and the like, which will, later, be given due attention. It will be best to consider first what the meaning of the records would be, were each number a perfectly true statement of the relative strength of the interest or ability in question.

Consider then this sample record as perfectly true and compute from it the differences between each subject's position for interest in the last three years of the elementary-school period (column 1) and for the high-school period (column 3).

[1] Other hand work means carpentering, sewing, gardening, cooking, carving, etc.

We have:

Mathematics	0
History	3
Literature	0
Science	3
Music	2
Drawing	1
Other hand-work	1
Sum of the seven differences	10

These facts are repeated in the first column of Table 3.

TABLE 3

	I Difference Between El. Interest Rank and H. S. Interest Rank	II Difference Between El. Interest Rank and C. Interest Rank	III Difference Between H. S. Interest Rank and C. Interest Rank
Mathematics	0	1	1
History	3	0	3
Literature	0	0	0
Science	3	1	2
Music	2	0	2
Drawing	1	0	1
Other hand-work	1	0	1
	10	2	10

Computing the other differences as shown in the second and third column of Table 3, we have for this individual the means of answering question 1, concerning the permanence of interests. If the individual had remained unchanged in his interests from any one period to any other the appropriate seven differences of Table 3 would obviously have been all zeros and the sum of that column would have been zero. If, on the other hand, he had from one to another period, changed as completely as possible, the sum of the appropriate column of Table 3 would have been 24 (7–1, 6–2, 5–3, 4–4, 3–5, 2–6, 1–7 giving 24). If the individual's interests had been due to mere caprice, changing their relative strength at random, the sum of any column of Table 3 would approximate 16. For, if a 1 is equally likely to become a 1, 2, 3, 4, 5, 6 or 7, and so also of a 2, a 3, a 4, etc., the average result will be 16.[2]

Any quantity below 16 as the sum of a column then means some permanence of interests in the individual in question, and the degree of permanence is measured by the divergence from 16 toward 0.

For the permanence from the elementary-school period to the junior

[2] 1 becoming 1, 2, 3, 4, 5, 6, 7 gives as differences 0, 1, 2, 3, 4, 5, 6;
2 becoming 1, 2, 3, 4, 5, 6, 7 gives as differences 1, 0, 1, 2, 3, 4, 5;
3 becoming 1, 2, 3, 4, 5, 6, 7 gives as differences 2, 1, 0, 1, 2, 3, 4.
Continuing and dividing the sum of the 49 differences by 49 we get 2 2/7 for the average difference by mere chance shifting and 7 × 2 2/7 or 16, as the average sum of a column in Table 3 by mere chance shifting.

year of college or professional school in my hundred individuals this figure is, on the average 9, three fifths of the individuals showing sums of from 6 to 12 for column 2 of Table 3. This average result of 9 may be expressed as a coefficient of correlation or correspondence, such as is in customary use to measure resemblances of various sorts. It is equivalent to a correlation of over .60. This means that a person's interests in the late elementary-school period resemble, in their order and relative strength, the constitution of interests which he will have eight years later to the extent of six tenths of perfect resemblance. For the coefficient of correlation is a magnitude running from — 1.0, which would be the coefficient if the sum of differences was 24, through 0, which would correspond to a sum of differences of 16, to + 1.0, which would correspond to a sum of differences of 0. A sum of differences of 8 means a resemblance greater than half of perfect resemblance, as the reader expert in the mathematics of probability will realize. The sums 12, 10, 8 and 6, in fact, mean coefficients of resemblance or correlation of + .38, + .55 + .71, and + .83, respectively.

The effect which the errors to which the original reports are subject would have in making this obtained degree of permanence too high or too low may now be considered. The chance errors—the mere failures of memory or carelessness in report or inability to distinguish slight differences in the interest of nearly equally interesting subjects—would make the obtained estimate *too low*. Their action would be to change the true sum of differences, whatever it was, toward 16, or the true coefficient of correlation toward zero. The effect of errors of prejudice, on the other hand, might have been toward so distorting memory and observation as to make the order given for interests in the two later periods more like the order given for the elementary-school period than was in truth the case. This would, of course, unduly raise the obtained estimate of permanence (that is, lower the sum of the differences). I do not believe that such tendencies to read present interests into the past and to leave the order reported for one period unchanged so far as possible, are very strong, there being a contrary tendency to remember and look for *differences*. On the whole, I should expect the effect of the large chance errors in *lowering* the estimate of permanence to nearly or quite counteract whatever balance of prejudice there may be in favor of similarity of interests or projection of present conditions into the past.

A correlation of .6 or .7 seems then to be approximately the true degree of resemblance between the relative degree of an interest in a child of from ten to fourteen and in the same person at twenty-one.

Consider now the difference between a subject's rank for interest and its rank for ability at the same period. Using the same sample record (Table 2) and assuming it to be a true record of the order of interests

and computing from it the difference between each subject's position for interest in the elementary-school period (column 1) and its position for ability in the same period (column 2), we have:

Mathematics	0
History	0
Literature	0
Science	0
Music	0
Drawing	0
Other hand work	0

These facts are repeated in the first column of Table 4. Similar facts for this same individual, for the differences between the order for interest and the order for ability in the high-school period and in the college period are given in the second and third columns of Table 4.

Table 4

	I Differences Between El. Interest and El. Ability	II Differences Between H. S. Interest and H. S. Ability	III Differences Between C. Interest and C. Ability
Mathematics	0	1	2
History	0	1	0
Literature	0	1	1
Science	0	3	1
Music	0	2	2
Drawing	0	2	1
Other hand-work	0	0	1

If at any period an individual has greatest ability in the subject which is most interesting to him, next greatest ability in the next most interesting subject, and so on, the sum of the seven differences for that period will be zero. If the order of ability was as unlike as possible to the order of interest this sum would be 24, and if the relation between interest and ability was that of mere chance this sum would be 16. Any quantity below 16 as the sum of a column in Table 4 then means some positive relation or resemblance between the individual's degrees of interest and his degrees of ability.

For the hundred individuals studied this figure is on the average approximately 5, being practically the same for the elementary-school period, for the high-school period and for the college period. This average result may be expressed as a coefficient of correlation of .88. Nearly three fourths of the individuals show records between 2 and 8, inclusive—that is, correlations of from .70 to .98.

If, in the case of any individual, we add together the three ranks for each subject in interest at the three periods and do likewise for its ability-ranks, we have measures of the general order of the seven subjects

for interest and for ability over the whole period from, say, the age of eleven to the age of twenty-one. Thus, in the sample chosen, the combined ranks give:

	Sum of Ranks for Interest, All Three Periods	Sum of Ranks for Ability, All Three Periods
Mathematics	10	7
History	6	5
Literature	6	6
Science	8	12
Music	17	17
Drawing	17	18
Other hand-work	20	19

Turning these into positions from 1 to 7, we have:

	General Rank for Interest	General Rank for Ability
Mathematics	4	3
History	1½	1
Literature	1½	2
Science	3	4
Music	5½	5
Drawing	5½	6
Other hand-work	7	7

The differences in the order are then 1, ½, ½, 1, ½, ½ and 0, their sum being 4.

I have made the calculation for each of the hundred individuals. On the average this sum of differences is approximately 4½, and corresponds to a coefficient of correlation of .91. The individual whose interests follow his capacities least closely still shows a substantial resemblance (nearly .5). The correlation between an individual's order of subjects for interest and his order for ability is in fact one of the closest of any that are known. A person's relative interests are an extraordinarily accurate symptom of his relative capacities.

The effect which the errors to which the original reports are subject is on the whole probably to make this obtained degree of resemblance between interest and capacity too *low*. Errors due to accident, carelessness, and inability to distinguish or to remember slight differences in interest or in capacity, would make the sums of difference in the long run greater—and the degree of resemblance obtained, less—than the true facts, would have given. The only sort of error that could make the obtained resemblance *greater* than the true fact would be an error whereby either order was falsified to make it more like the other, notably, the possible tendency to rate oneself higher than one should for ability in a subject which one likes. On the whole, the resemblance

between interest and ability may safely be placed at about .9 of perfect resemblance.

I have computed the resemblance between *interest in the last three years of the elementary* school and *capacity in the college period* as a partial measure of the extent to which early interest could be used as a symptom of adult capacity. The average for the hundred individuals is a coefficient of correlation or resemblance of .60.

I have also, for comparison with the last measurement and with the measurement of the resemblance of interest in the late elementary period to interest in the college period, computed the coefficient of correlation or resemblance between the order of the seven subjects for *ability* in the elementary and their order for *ability* in the college period, using the records from these same hundred individuals. The average resemblance obtained is six and a half tenths, or slightly closer than that for early and late interest.

These facts unanimously witness to the importance of early interests. They are shown to be far from fickle and evanescent. On the contrary, the order of interests at twenty shows six tenths of perfect resemblance to the order from eleven to fourteen, and has changed therefrom little more than the order of abilities has changed. It would indeed be hard to find any feature of a human being which was a much more permanent fact of his nature than his relative degrees of interest in different lines of thought and action.

Interests are also shown to be symptomatic, to a very great extent, of present and future capacity or ability. Either because one likes what he can do well, or because one gives zeal and effort to what he likes, or because interest and ability are both symptoms of some fundamental feature of the individual's original nature, or because of the combined action of all three of these factors, interest and ability are bound very closely together. The bond is so close that either may be used as a symptom for the other almost as well as for itself.

The importance of these facts for the whole field of practise with respect to early diagnosis, vocational guidance, the work of social secretaries, deans, advisers and others who direct students' choices of schools, studies and careers, is obvious. They should be taken account of in such practise until they are verified, or modified by data obtained by a better method: and such data should be soon collected. The better method is, of course, to get the measurements of relative interest and of relative ability, not from memory, but at the time; and not from individuals' reports alone, but by objective tests. Such an investigation requires a repeated survey of each individual at three or more periods, say in 1912, 1915 and 1920, and demands skill and pertinacity in keeping track of the hundred or more children and arranging for the second and third series of reports and tests. I hope that some one of my readers will be moved to undertake it.

CHINA'S GREAT PROBLEM

By Professor THOMAS T. READ
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NEITHER the institution of republican forms of government, nor the creation of a spirit of natural unity, not even the inculcation of republican ideals constitutes China's great and imminent problem. It is not inappropriate that a nation whose people are best known for their skill and probity in business affairs, at the close of revolution engendered in large part by financial considerations and brought to a speedy termination by that modern arbiter of warring factions and nations, the international money lender, should find her most imminent and pressing problem a plain one of business. The average man finds it necessary to give constant consideration to the relation between his income and expenditures and to possible sources of increase of the one and diminution of the other. Nations are no more fortunate and China is unusual only in that her monetary affairs, through her international loans, have become matters of cosmopolitan importance.

At the beginning of last year China had a total foreign indebtedness, secured by Imperial revenue, of approximately $700,000,000,[1] corresponding to an annual interest charge of approximately $35,000,000. During the year a budget was prepared, the first in the history of the nation, which showed that the estimated annual income of the empire was some $180,000,000. The budget made evident to all what many had long known, that China was unable to make both ends meet, and like a spendthrift was using her capital to pay her debts. The fundamental causes of the revolution of 1911 have been much obscured by the natural human desire to weave adventure and romance into war, but it is true, nevertheless, that just as the "embattled farmers" were irritated beyond bearing by a tax on tea, so were the "sons of Han" roused to arms by burdening them with a foreign loan of which they did not approve.

It will be remembered that after the American financiers who had acquired a concession to build a railway from Hankow to Canton perfidiously sold it to the Belgian interests, whom the Chinese especially wished not to secure it, the concession was bought back by China and the people of the provinces through which the road passed attempted to

[1] Only approximate figures can be given, for the varying rates of exchange and diverse rates of interest make exact figures impossible.

raise the funds for its construction. Considerable sums were raised, but were neither wisely managed nor well spent, and as time passed the funds gradually melted away without any material return in the form of roadbed and rolling-stock. Meanwhile, centralization of power in the Peking government was increasing with rapid strides, and finally the Peking authorities began to negotiate with England, France and Germany a loan for the construction of this and other railways. The means by which the United States claimed and secured the right of participation in this loan, while of importance to China as well as the banker powers, is outside the present question. It was evident from the first that there was great popular opposition to the loan, and foreigners, who knew the popular temper, prophesied that it could never be consummated. Finally the negotiations were concluded, however, and the terms were announced. Among other provisions it was announced that for the sum already spent by the people of the provinces, stock in the railway enterprises to half its par value would be allotted. The pot of revolution, which is always seething in southern China, at once boiled over. The Chinese people had suffered an incompetent government by alien officials as long as it did not greatly trouble them. When it began to waste their money they promptly revolted.

It is generally agreed that war is hell. It is also expensive. Bombardments, bloody combats, fire and looting figure in the head-lines of the daily journals, but the real work of the revolution was done in the financial council chamber. At the beginning of the outbreak neither side was provided with adequate funds, for the revolutionists were unable to secure any considerable sums, though able to cut off a large part of the normal income of the Peking government, and the imperial household with business caution refused to give up their store of private treasure for what bade fair to be a losing contest. The struggle at once resolved itself, therefore, into a competition to secure foreign financial assistance.

Perhaps some day the true history of the negotiations at Peking and Nanking will be made known. But from a business standpoint it was at once evident that the Peking government had immensely the more advantageous position. It had for some time been in negotiation with representatives of the banker nations in regard to loans, and was easily able to continue its negotiations. Bankers seek for stability and naturally preferred to deal with a government whose peculiarities had been learned through years of experience, rather than to take a chance with an oriental republic, of which it would be safe only to prophesy that it would do the unexpected. The revolutionists were out of touch with the financiers, many of them were young and inexperienced, and they were unable to make any impression except upon the Japanese and Russians, who hoped that after a new deal in China they might hold a better hand.

The Chinese are an eminently reasonable people; their natural motto is to suit themselves to circumstances. When it became clear that the revolutionists could not secure funds to put themselves in control of the country, and that the Peking government, while it could secure funds upon evidencing an ability to tranquillize the country, could not do so as long as the Manchus remained in nominal control, the inevitable followed. The Manchu emperor and his associates gracefully abdicated, announcing that the will of Heaven, speaking through the voice of the people, desired the institution of a republican form of government, and the revolution was *fait accompli.*

In the months which have since elapsed China has been crowded from the stage of international attention by other affairs, yet the negotiations which have been going on are of even greater importance than the more spectacular events of the war. The banker powers are good business men, and, having an opportunity to make China "pay through the nose," were not unlikely to underestimate it. The Chinese are business men, too, and struggled to secure as favorable terms as possible. The difficulty was a complex one—China wished to avoid Egyptianization, while the powers wished to be sure that their money would be well spent, and reasonably secure, while inextricably interwoven were the political aspects of the loan. The Chinese played their ancient game of pitting one interest against another. Many loans were proposed, a loan of $30,000,000 from Baron Cottu was seriously considered, and part of an Anglo-Belgian loan was paid over. The four powers which had been in negotiation for the past two years were increased to six by the addition of Russia and Japan, and finally to seven by the addition of Austria before it was agreed that all other loans should be abandoned and $300,000,000 advanced to China by this septuple syndicate in a series of instalments.*

The problem has not been solved, however; only expanded. Soon China will be indebted to foreign nations by nearly $1,100,000,000, a greater sum than the national debt of the United States. This calls for an annual interest payment of over $50,000,000, over and above the expenses of government. Her total annual income has so far apparently been about $180,000,000 or about one fourth that of the United States. In other words, to an already large annual deficit she has added an annual interest charge of over $15,000,000. Can she increase her income to meet it? A corporation in such a precarious situation would procure the services of the ablest business manager whom money could secure. China's problems are fit tasks for supermen: will the supermen be forthcoming?

* Since this article was written the republican government has refused to accept this loan on the terms proposed. The fundamental problem means essentially the same.

A brief survey of China's economic condition will be of service. In former times China was like a "balance-tank" in an aquarium, self-supporting. As Ross has recently accurately remarked, the nation is an exemplification of the law of Malthus, the balance between population and means of existence. To us of America a true mental picture of the economic status of the Chinese is almost an impossibility. A comparison may serve, and by pointing out that the present degree of comfort and convenience enjoyed by the average Chinese demands a coal production 1/175 of that in the United States, and until recently an iron and steel production only 1/1,200 that of the United States, it may be more clear that the Chinese nation as a whole is close to the margin of mere existence. The problem with the average Chinese is an elemental one; enough food to preserve life and enough clothes to keep warm and subserve modesty. China's present unenviable position is not unlikely largely due to the fact that when international trade developed and the export of tea began to meet the import of the ubiquitious blue cotton cloth that forms the Chinese national dress, the acreage formerly devoted to the cultivation of cotton was sown to the opium poppy and the national wealth vanished in curls of smoke that wafted away at once the substance and virility of the people.

Now the use of opium is almost suppressed, soon will be completely so, and the land devoted to its cultivation, will be sown to grain, sugar beets and other crops of real value. The problem is still an elemental one, however. It is idle to simply point out that by opening mines, building railways and developing manufacturing industries, the scale of living of the Chinese citizen can be raised to approximately as luxurious a plane as in the United States. The real question is—will the increase in the wage of the average citizen bring him increased comfort and convenience, or will it bring a few more mouths to feed and another approximation to the margin of existence? If the latter, the Chinese expression for the management of a household—"Kuo jih-tze" to get over the day—will remain always, as now, the index of national economy. Upon the answer to this question hangs China's future.

The further elaboration of this topic would take me into a field in which I scarcely dare venture. It is still a subject of discussion in this country whether the restriction of the size of families is compatible with good morals and good economics. Apparently the pragmatic answer is in the affirmative. The great desire of the Chinese parent for offspring to maintain the rites of ancestral worship further complicates an already complex problem and I will leave it in abeyance, in order to discuss the problem of securing national prosperity from the standpoint of the scanty facts available.

Of China's present foreign indebtedness nearly $350,000,000 represents indemnities, largely the outcome of the outbreak of 1900. The

remainder has partly been invested in railway and other industrial enterprises, and partly used in a variety of minor ways. To meet the interest and principal upon this debt the returns of the Maritime Customs has been the security, and the service has for years been under foreign direction. Besides being a source of income the custom service has been an object lesson and a training school for the Chinese. Out of it has grown the excellent postal, telegraph, and telephone service which China enjoys. In 1905 35,110,000 taels[2] were collected from the import and export tax on merchandise. In the budget recently published in the Chinese press, following the address given by President Yuan before the National Assembly, the expected receipts from the Maritime Customs this year is given as 35,140,000 taels. The growth is inconsiderable while the fluctuations in exchange during the past year correspond to a difference of about 5,000,000 taels in the conversion of this sum into gold.

Consideration of this budget as a whole offers an interesting study and I therefore give the estimated revenues and expenditures under the new government, as printed in Chinese journals, and translated by the well-informed *National Review* of Shanghai.

ESTIMATED REVENUE

Ordinary

Land Taxes	46,164,709
Salt and Sea	46,312,355
Maritime Customs	35,139,917
Native	6,990,845
Sundry Duties	36,136,842
Likin	43,187,907
Income from Official property	36,600,899
Sundry Receipts	19,194,101
Total	Tls. 269,754,579

Provisional

Land Taxes	1,936,636
Native Customs	8,524
Contributions	5,652,333
Government Credit Notes	3,560,000
Sundry Receipts	16,050,648
Total	Tls. 27,208,142
Grand Total	Tls. 296,862,721

[2] The tael is a Chinese ounce of silver, and has different values at different places. The customs tael = 1.0164 Kuping tael. The latter is 575.8 grains of pure silver, and is doubtless the tael used in the budget. Naturally, its value in gold varies according to the rate of exchange.

Estimated Expenditure

Ordinary Expenditure

Executive Affairs	26,069,666
Foreign Affairs	3,375,130
Interior Affairs	19,735,787
Financial	17,703,545
Maritime Customs	5,748,237
Native Customs	1,460,332
Commercial Affairs	745,759
Educational Affairs	12,801,468
Judicial Affairs	6,616,579
Naval and Military Affairs	83,498,811
Industrial Affairs	5,315,606
Communications	48,898,355
Works	2,511,257
Official property	7,696,361
Provincial Indemnities	39,120,732
I. M. Customs Indemnities	11,263,547
Native Customs Indemnities	1,256,491
Territorial	1,239,908
Total	Tls. 295,256,882

Provisional Expenditure

Executive Affairs	1,258,184
Foreign	626,177
Financial	2,877,904
I. M. Customs	9,163
Native Customs	40,576
Civil Affairs	2,724,974
Commercial	54,037
Educational	3,348,061
Judicial	218,746
Naval and Military	14,000,540
Industrial	667,154
Communications	7,804,908
Works	2,576,137
National Credit Notes	4,772,613
Total	Tls. 40,979,180
Grand Total	Tls. 336,236,062

Lest the reader be unduly impressed by the appearance of accuracy given by carrying out these sums to the nearest unit, let me add that the probability of error in them is very great and other published estimates put the expenditure as high as 576,000,000 taels, while the Board of Revenue in 1910 prophesied a deficit of 80,000,000 taels in 1911. The indicated deficit of 40,000,000 taels may therefore be regarded as a fairly optimistic view of the financial situation.

As to expenditure, it is seen that over 50,000,000 taels is required to pay interest on indemnities. Communications (railways, post-office

and telegraphs) consume nearly an equal sum and return only about two thirds as much in the form of revenue, the difference being partly due to expansion and partly to a present lack of profits from many enterprises. Naval and military affairs consume a large sum, but the present temper of the Chinese public is strongly contrary to a reduction of the effort to make China self-protecting. Educational expenditures should be increased, rather than curtailed, and it may similarly be said of most of the other items that though the moneys might perhaps be more wisely and efficiently expended they can not very well be decreased if the country is to prosper. China's hope lies, not in decreasing her expenses, but in increasing her income.

To greatly increase the income from the Maritime Customs scarcely seems feasible. The present rate of 5 per cent., imposed equally on imports and exports, is certainly low, but the commercial treaties existing with the principal countries only provide for a moderate increase, and it scarcely seems possible that the banker nations would look with favor upon a proposal to tax foreign trade in order to secure income to meet the interest upon their loans. The likin (internal transit tax) should be abolished; like the ridiculous prohibition of the export of grain from one province to another, it hangs like a vampire on the industrial body of the nation, sucking out its life. The conception that certain parts of the country are best suited to the production of certain commodities, while others can best produce something else, and that the best interests of the whole are secured by offering every facility for the free exchange of products, is so elementary that it is strange that even such pronounced individualists as the Chinese have not earlier perceived it. The salt gabelle, similarly, is a financial anachronism. The income from the government-owned enterprises can be greatly increased by better, more intelligent, more careful, and more honest management. In fairness it should be said that the lack of profits from these is not all to be laid at the door of the Chinese; foreign engineers have built $40,000,000 railroads where the probable trade only justified a $10,000,000 road, and foreign supervision of enterprises has often brought with it fat contracts for the foreign merchant.

The land tax might be increased, but the farming class, the large landowners, are already barely above the margin of subsistence, as a whole. But by development of agriculture, as in the United States, the income of the farming class could be greatly increased, with a corresponding taxable margin. Agriculture is the fundamental industry of any country, and the new government will be stupidly negligent if it does not make provision for its scientific development. Progress has already been made in this regard in Manchuria. The improvement of yield and of product by the judicious selection of seed is an idea which has never occurred to the Chinese; indeed, it may be broadly said that

the improvement of anything by the elimination of its bad features and increasing of its excellences has never characterized Chinese industrial activity in recent times. I think it unquestionable that the people of China can be better fed and made correspondingly more vigorous simply by government aid to agriculture and the allowing of the free transit of the products of one part of the empire to any other part. The productive energy of the nation as a whole can thus be immensely increased. The human body is an engine for the conversion of food into useful work. Like any other engine, if it is supplied with only enough power to keep it going the useful output is small, since nearly all is used up in driving the machine. But give it all the power it can economically use and the useful output is many-fold greater. The simile is a crude one, but none the less accurate.

It will be noticed that no provision is made for the taxing of incomes, or of industrial enterprises. Under the old system either the tax on land or the tax on trade reached nearly all of these. This is no longer the case and such companies as Standard Oil, British-American Tobacco, Singer Sewing Machine, and numerous native enterprises carry on a large trade without being subject to any tax. This will constantly increase, and by the imposition of a just tax on these new forms of industry considerable sums can be derived. Every means should be taken to encourage the development of such enterprises. The mineral resources of China should be studied and mapped by qualified engineers, the country should be mapped topographically as an aid to the development of railway, irrigation and industrial enterprises, and every effort should be made to increase the agricultural and mineral productivity. A well-fed people with material to work with can upbuild China into a nation of solid wealth and substance. But if the proceeds of the new loan are expended unwisely and unprofitably then China must inevitably within a few years become another Persia. Business principles, rather than political considerations, must be preeminent in the conduct of the new government.

MODERN WARFARE AGAINST GRASSHOPPERS

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IN all probability there will never be in the middle west a repetition of such uneasiness and alarm as prevailed during the early seventies in the states of the upper Mississippi and Missouri valleys, on account of the so-called Rocky Mountain grasshopper, *Melanoplus* (*Caloptenus*) *spretus.* Entomologists living in the area bounded by the Rockies on the west and the Mississippi Valley on the east report that for many years they have been unable to collect a baker's dozen of this long-winged locust east of the western plains, which represent occasional breeding grounds of this at one time destructive species, or in the foothills of the Rockies, believed to be the source and permanent breeding grounds of the pest, although it is reported that a few individuals have recently been captured in the Rocky Mountain districts. The passing of this insect may be in slight part due to the settling up of much of the country formerly utilized by them as breeding grounds, either temporarily or permanently. But so suddenly has it disappeared, and so markedly has been the increase of an allied shorter-winged form, *M. atlanis* (the lesser migratory locust), closely resembling *M. spretus,* that a suspicion exists that the latter may have been a varietal and, we may say, a sporadic form of the first named. Farmers, however, and others in the region indicated, must rid themselves of the idea that the winged visitor from the Rockies which, years ago, laid waste their fields, is the one grasshopper to be dreaded. Indeed, they are beginning to realize that in the rapid increase of some of our common species, which we may refer to as "native" species, there exists a serious menace to successful farming. Any grasshopper or locust is injurious in proportion to its abundance, and during the last three years a marked increase of a few of our common forms, and the accompanying and yearly increasing injury to crops, constitute a "writing on the wall," as it were, well calculated to rouse citizens from a feeling of absolute security to an appreciation of the need of practical measures of control. This menace is of interest not only to farmers, but naturally also to business men in any community so afflicted, since the business prosperity of a locality depends very largely on the prosperity of the farmers.

The farmer living in a neighborhood under complete cultivation, containing but a small amount of untilled land, has little to fear, but

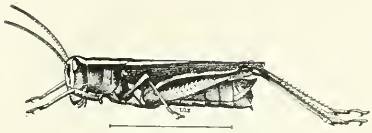

FIG. 1. TWO-STRIPED LOCUST OR GRASSHOPPER (*Melanoplus bivittatus*), FEMALE.

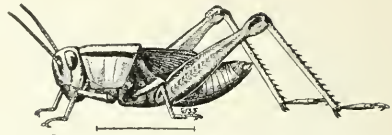

FIG. 2. TWO-STRIPED LOCUST OR GRASSHOPPER, YOUNG FORM. Representing stage best adapted to be killed by poisonous spray.

FIG. 3. LESSER MIGRATORY LOCUST OR GRASSHOPPER (*M. atlantis*), MALE.

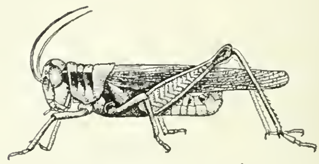

FIG. 4. DIFFERENTIAL LOCUST OR GRASSHOPPER (*M. differentialis*), MALE.

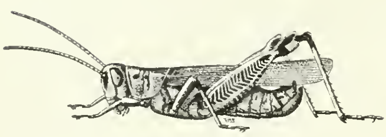

FIG. 5. PELLUCID LOCUST OR GRASSHOPPER (*Camnula pellucida*), MALE.

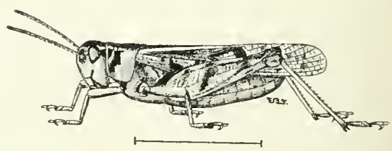

FIG. 6. THE RED-LEGGED LOCUST OR GRASSHOPPER (*M. femur-rubum*).

FIG. 7. THE SHORT-WINGED LOCUST OR GRASSHOPPER (*Stenobothrus curtipennis*), MALE.

those endeavoring to raise crops in districts where there are hundreds of acres of virgin land untouched by the plow, or large tracts of "reverted" land, land which though once cropped has been allowed to revert to natural conditions, may well look with apprehension upon the accumulating hordes of what they used to regard as harmless grasshoppers in contradistinction to the much-dreaded Rocky Mountain locust. It is such localities that offer ideal conditions for the increase of this insect. Evidently, therefore, farmers living on the frontier of agricultural areas next to new or reverted land, the pioneer farmers, as it were, are the ones to suffer most heavily. Given such localities and dry weather, the absence of heavy, killing rains, when the young hopper is just out of the egg for a succession of seasons, and the agriculturist sees acres of wheat, oats, rye, barley and flax rendered so nearly worthless that they do not warrant the labor of harvesting. During 1909, 1910 and 1911 several species of grasshoppers have been increasing to such an extent in a number of states in the middle west that special remedial measures have been necessarily sought. A few of these states have created grasshopper laws, aimed at the obligatory destruction of egg clusters in fall or spring by compulsory plowing. These laws, however, are, in most instances, notoriously ineffective, and some practical method or methods of control within the reach of the average farmer had to be discovered. Manifestly, these measures of relief must be such as to enable the individual farmer to protect himself, no matter how unfavorable the conditions surrounding him. It was to solve this problem, as far as lay in his power, that the writer and his staff have applied themselves for two years, and it is believed that we have found a fairly sure means of crop protection if our farmers will follow directions emanating from the Experiment Station. While our experience has been confined necessarily to Minnesota, these remedies are equally applicable in other states, where the same or worse conditions prevail. In fact, we would not convey the impression that Minnesota is a grasshopper-stricken state; far from it, for a very large proportion of our agricultural land, most of it, in fact, is relatively free from this pest, but we seek to protect from loss those individual farmers, pioneer farmers we have called them, who live in the western quarter of the state in the neighborhood of vast tracts of unused lands, property held by speculators, unsalable tracts, acres held by individual farmers who have more land than they can handle, land occasionally rented, and between rentals lying idle, a menace to adjoining properties of industrious citizens doing their best to get a living from the soil. Manifestly fall plowing, thus burying the eggs deeply, will not be of material benefit to these men, for the hungry hordes will pour in upon their tender grain from the adjoining fields, whose owners, not easily reached by our grasshopper laws, are indifferent. True, such a farmer can and

FIG. 8. A HOPPER-DOZER IN ACTION.

does get some relief by the constant use of the old-time "hopper dozer," driving it back and forth over his fields while the grain is young. He may, if there is no hay crop at stake, and at some considerable risk to fences and buildings, burn over fields where myriads of young hoppers are a few days old, if such fields are burnable; and he may successfully, and with considerable profit to himself and family, protect his vegetable garden with a flock of grasshopper devouring turkeys. Yet none of the above measures is sufficient to obtain the results necessary to successfully meet existing conditions, none of them makes a sufficient impression upon the hordes of grain-devouring insects. The exigencies of the case prompted the writer to experiment with a poison spray (arsenite of soda) found successful in South Africa. Our legislature of 1910–11, influenced by the fact that these pests were on the increase, and that in 1910 the state lost almost or quite two thirds of its flax crop through the work of grasshoppers, granted a small appropriation for two years' work against this insect, under the direction of the state entomologist. With these funds available, we were enabled to employ four specialists in the field during the summer, to buy spraying outfits and spraying material, and to visit and personally help individual farmers asking aid.

The mental attitude of many of these citizens toward this work is interesting. In the first place, in the winter, an apathetic condition prevails; the lesser losses are forgotten, "Hope springs eternal," etc., but in the summer, too late for efficient work, our office is deluged with mail from the same farmers who, in the late fall and winter, expressed

doubts as to the recurrence of the trouble. And then, too, we have the more or less shiftless renter who says, "No, I do not think I will do anything—hardly worth while—I move next year." We find, too, a certain class, foreigners mostly (a large portion of Minnesota farmers are Scandinavians), who feel that the state should send men to their fields at its own expense, protect their crops by the state's efforts, and, incredible as it may seem, in some instances, pay them (the farmers) a generous board bill at the same time. Then, too, many of the real estate men in a locality more or less afflicted, look with disfavor upon efforts naturally attended with some publicity, to instruct the farmers in methods of control, claiming it injures business.

The misconceptions regarding grasshoppers and locusts which prevail, and the consequent errors which creep into print, are amazing, the most common one possibly being confounding of one of the harvest flies, or so-called seventeen-year locust, with the true locust or grasshoppers. The seventeen-year locust or periodical cicada, which, by the way, is as yet lacking, or extremely rare in Minnesota, is a sucking insect and belongs to an entirely different order than that of locusts or grasshoppers. One can imagine, then, the feelings of an entomologist upon beholding the following newspaper comment, placed upon the front page with startling head-lines: "*Within the past week several farmers have seen the genuine red-legged, seventeen-year, or Rocky Mountain locust flying high in the air.*" We have used the term "grasshopper" repeatedly in this article, because it is a popular

FIG. 9. REMOVING DEAD HOPPERS FROM HOPPER-DOZER.

term for these insects, but scientifically erroneous, for the species particularly injurious, in that they are the most numerous, belong to the family *Acrididæ,* while the true grasshoppers, having long antennae, and ordinarily more or less sharply pointed heads, belong to the family *Locustidæ.* The common error of calling the periodical cicada and other species of cicada "locusts" adds to the popular confusion. Of the injurious Acridids found in Minnesota only four species are sufficiently numerous to warrant our classifying them at this time as a serious menace to crop growing, namely, the lesser migratory locust, *Melanoplus atlanis;* the two-striped locust, *Melanoplus bivitattus;* the

Fig. 10. Spraying for Grasshoppers with Arsenite of Soda.

red-legged locust, *M. femur-rubrum;* the differential locust, *M. differentialis,* to which we may add, possibly, the pellucid locust, *Camnula pellucida,* and the short-winged locust, *Stenobothris curtipennis.* All of these yielded to a poison spray made by dissolving three pounds of arsenite of soda in 180 gallons of water, and adding to this solution one and one half gallons of cheap molasses. This is essentially the South African formula, though in spraying the veldt a much stronger solution was used in Africa, so strong, in fact, that vegetation was killed, a fact of little import under the conditions in the African campaign, but of the utmost importance where, as in the middle west, pastures or even grain fields have to be treated. We found that at the strength used by us no appreciable injury was evident, and although it took

from 24 to 36 hours for the insects to die after partaking of the poison, a partial paralysis was the result, and no food was taken by the afflicted animal after his poisoned meal. We applied this by means of large field sprayers, the spray covering 23 lineal feet of ground at once, though the ordinary potato sprayers could also be used. Generally speaking about fifty gallons will cover an acre, and the cost per acre, exclusive of labor, is about 30c. This figure would, of course, be influenced to a greater or less extent by the location of the water supply. A tank wagon in the field would naturally lessen waste of time in this connection. The question as to the effect of this poisoned forage upon stock naturally presents itself at this point, and we have reason to say

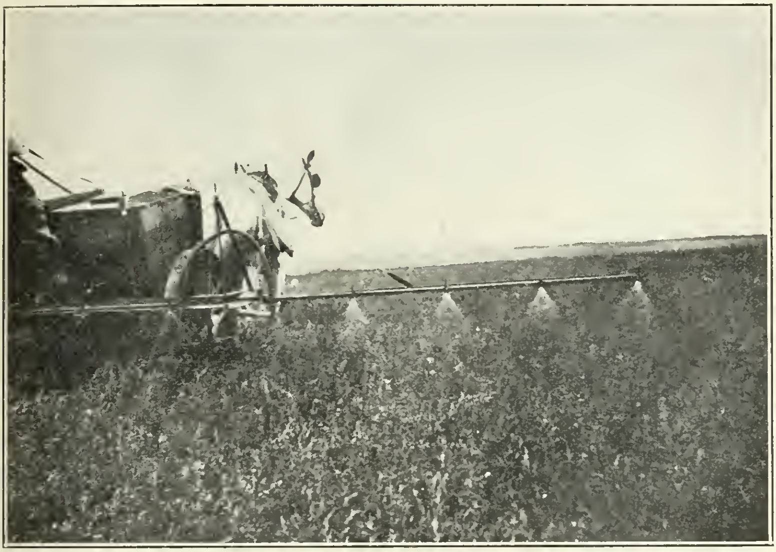

FIG. 11. ANOTHER VIEW OF OUR SPRAYING OUTFIT.

that, as used by us, there appears to be no danger from this source. Of course, unrestricted feeding upon grass drenched with a poison spray on the part of animals, forced to use such feed, and allowed no other forage, might, and probably would, have bad results, but in ordinary practice, as applied in a grasshopper campaign in North America, such conditions would not present themselves, albeit the farmer must bear in mind that he is handling an internal poison, cumulative in effect, the partaking of which in large quantities would probably mean death to any animal.

To be more explicit, the above opinion is based upon several experiments we have tried personally at the Minnesota Experiment Station, the following, and last, constituting sufficient proof to warrant the statement. A yearling heifer was placed in an enclosed plot containing

$\frac{1}{10}$ of an acre, after the grass thereon had been poisoned with the arsenate of soda spray (strength given above) at the rate of sixty gallons per acre. The animal cropped freely upon this without any ill effect. This poisoning of the grass was repeated twice thereafter, and after allowing her to remain several days in the inclosure after the third spraying, she was removed, to all appearances in even better condition than at the beginning of the experiment.

It is only from an actual test like this that one is justified in mak-

FIG. 12. MITES ON A GRASSHOPPER.

ing a statement and even in this case we qualify it by reminding the farmer that carelessness with the mixture might cause a fatal accident. Nevertheless it is evident that, properly used as directed against grasshoppers, no such severe tests as above would arise.

Many will remember a legal case in a western state where a smelting company was sued by a stock owner on the ground that the latter's pasturage was poisoned by arsenic coming from the smelters and the consequent death of the stock. The interesting point of this suit was the fact that the loss did not occur until after several months' feeding on the grass claimed to be poisoned.

An obstacle met with by the farmers in a practical application of this method is the difficulty they experience in obtaining arsenate of soda in sufficient quantity, and at reasonable cost, from the country druggist at the time when it is most needed. The most effective time to spray, and also the most economical, is shortly after the "hoppers" hatch, and long before they obtain wings, and the average farmer is not far-sighted enough to lay in a supply of the poison before hand. It is

to be hoped that this difficulty, the chief obstacle in connection with spraying, will be overcome.

While advising spraying, we do not lose sight of the older methods, more or less effective, that entomologists have been urging upon farmers in years past: the old time "hopper-dozer" with kerosene in the pan, late fall plowing, a flock of turkeys to protect the garden, etc. Our work, however, has resulted in throwing doubt upon the effectiveness of some of the generally accepted methods and has made it necessary to qualify statements made in all good faith from time immemorial. For example, the entomologist, when the farmer has declared that a large number of grasshoppers jump out of the hopper-dozer and are not killed, assuming an air of wisdom, has said, "No, if they only touch the kerosene they are bound to die, even if they appear to have escaped destruction at the time." Last summer's work has made it evident that this is only true of the short-winged forms, in which the oil can reach the spiracles; in others, where the wings cover these breathing openings and protect them as well as the body of the insect, they live to carry on the work of destruction. Again, farmers living in grasshopper-infested regions generally handle so much land that late fall plowing is impossible. As a rule, they begin to plow, in the latitude of Minnesota at least, in August, as soon as the crop is off the ground and the grasshoppers find no better place to deposit their eggs than in the plowed stubble.

Further, this advice is based largely upon the theory that if the "pocket" or capsule containing the eggs is turned upside down, or nearly so, the newly hatched hopper never gets out and perishes. It appears, however, that this view, accepted as a truth by each succeeding generation of entomologists, must be modified, for it is probable that the capsule, becoming soft and gelatinous by the action of the elements, or perhaps disappearing altogether by May, offers no obstacle to the imprisoned insect, and still further, we have no positive proof that the newly-hatched hopper can not ascend through many inches of the soil until the surface is reached. Laboratory experiments during the summer of 1912 indicate that the newly-hatched grasshopper may work his way through eight inches of fairly well packed soil.

Finally, it has been commonly believed, and is doubtless true of the majority of insects, that alternate freezing and thawing is fatal. But one of the field men exposed last winter about twenty young hoppers, hatched in the warmth of indoors, to alternately a freezing and thawing temperature several times, with no bad results to the insects, one only succumbing and that probably being injured in handling. These observations appear to leave open a large field for investigation along the lines of grasshopper control.

Grasshoppers have many enemies, but their numbers are so enor-

mous that the latter cause but little apparent depletion in their ranks. Many of our song birds eat them, as well as black-birds and crows. The sparrow-hawk's crop is filled with them in the fall, and at least one variety of tern helps the farmer materially in this direction. Skunks and other predatory mammals are partial to them, and we have personally observed the thirteen-lined gopher (*Sphermophilus tridecemlineatus*) catching and devouring them in the cool mornings of autumn. Among insect enemies, parasitic and predaceous flies are very useful in their attack upon the eggs as well as upon the hoppers themselves. Various beetles, notably some of the meloids or "Blister Beetles," insects which are themselves destructive to crops in the adult stage, make some amends for their destructiveness by preying upon the eggs.

Farmers, seeing small mites fastened to the wings and bodies of grasshoppers, have been wont to comfort themselves with the thought that these animals were reducing the number of the pests. Inasmuch as we have seen female hoppers in the fall, laden with these possible parasites, laying eggs for the next generation, having themselves completed their destructive life history, we believe too much reliance has been placed upon this phenomenon in the past and are inclined to regard their occurrence on grasshoppers as a means of dispersal of the species of mite in question, rather than a serious drain upon the vitality of the grasshopper.

It would seem, then, that the farmer must rely principally upon his own effort in this warfare, unless forsooth nature favors him by sending many cold drenching rains in May and June when the hoppers are hatching, which not only result in great mortality amongst the insects themselves, but give the crops such a stimulus that they are better enabled to withstand the inroad of these pests.

THE RELATION OF EUGENICS TO EUTHENICS

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NO attempt is made in the present paper to present a new array of facts nor to treat them in a novel light—even the title which has been chosen is not new, except perhaps in the arrangement of the words. But race improvement is a broad field, the cultivation of which is barely begun, and as in all cases when a new territory is to be occupied, a survey of the ground is of primary importance. Such a survey helps us in the formulation of definite plans for the systematic development of the land and saves much effort which might otherwise be misdirected. In what follows an attempt has been made to mark out some of the delimitations of our territory, the character of the soil, and consequently what crops—what lines of endeavor—may best be expected to succeed.

It is unfortunately true that a rich soil is equally suited to the growth of the grain or the weeds, the wheat or the tares. The harvest accords to the quality of the seed sown and to the diligence and intelligence applied to uprooting the undesirable plants. And just so it is with society. So long as we permit the marriage and the reproduction of the unfit in human society, we are countenancing the contamination of the seed which stands for the human crop of the next generation. The seed which we use must either be relatively free from weeds or we must put it through a winnowing process.

Every agriculturist knows the importance of continued cultivation in order to keep his land relatively free from weeds. A field allowed to go without attention or even kept down to a meadow for only a few years, soon "runs to weeds" to such an extent that the only procedure is to plow it under and put on some strong-growing crop, which will "kill out the weeds." In how far are these conditions comparable to those of our physical, moral, social and civic life? And if they are comparable, are we giving the attention we should to the winnowing of the seed? We shall also, of course, have to devote our attention to how this winnowing may best be accomplished.

Let me then be the surveyor who shall endeavor to map out our field, to determine its limits and demarkations and its relation to the neighboring fields on either side. Furthermore, let me try to chart its general physical features in an endeavor to ascertain how it may best be cultivated.

Our neighboring field on the right is that of biology—or more narrowly the field of genetics—but here we find indeed that our relationship is very close, that we possess in fact only one section of the big biological farm, and that, however big and important our corner may be, nevertheless, it is only a corner of the larger field of genetics. Our relationship is indeed here so close that we shall need no fence between us. We have, it is true, somewhat different conditions to contend with, but the same problems to solve, and by retaining our good fellowship, we may hope to receive much aid from this neighbor, whose conditions are in some ways much simpler than our own, and who can, therefore, make more rapid independent progress.

On the other side we are bordered by the field of euthenics. Unfortunately, we have not always, up to the present, been able to get along with this neighbor on the best of terms, but there is every reason why our relations should be amiable and friendly, cooperative and helpful; we both have the same objects in view—our ideals are the same, but we are not in thorough accord as to the methods by which they may best be attained.

Since the relations between the other biological sciences and eugenics are so obvious, let us examine a little more fully those between eugenics and euthenics. According to one of the foremost exponents of euthenic ideas in this country, euthenics means, "The betterment of living conditions, through conscious endeavor, for the purpose of securing efficient human beings," or "Euthenics deals with race improvement through environment," while "Eugenics deals with race improvement through heredity."[1] Galton himself defines eugenics somewhat more broadly as "The science which deals with all influences that improve and develop the inborn qualities of a race,"[2] though he must have had chiefly hereditary influences in mind, since he adds:

> The aim of eugenics is to represent each class or sect by its best specimens, causing them to contribute *more* than their proportion to their next generation; that done, to leave them to work out their common civilization in their own way.

We may conclude, therefore, that the point at issue between eugenics and euthenics is clearly that of the relative influence of heredity and environment in the development of the human race, and as such, we may proceed to discuss it further.

Whatever may have been the degree of controversy in the past and whatever may be the opinion of the practical breeder, the philosopher or the reformer, biologists are practically agreed that the environment can have no hereditary effect on organisms, at least in the crude way commonly inferred under the caption of the "inheritance of acquired

[1] "Euthenics, the Science of Controllable Environment," by Ellen H. Richards, Boston, 1910.

[2] *Nature*, Vol. 70, 1904, p. 82.

characters." Whether certain conditions are able to produce a general effect upon the germ cells of such a nature that it may cause a general modification of the resulting organisms for more than the immediately succeeding generations, may perhaps legitimately be considered still open to reasonable doubt. Such a possibility, however, does not come within the scope of our present argument and may be disregarded; and we may consider it as established to the best of our present biological knowledge that acquired characters are in no specific sense inherited.

Of course, there are euthenists who will not accept the principle I have laid down—to convince such would require an array of biological facts and experimental results which can not be presented at this time and which are not within the scope of my talk this evening, although one or two specific cases as applied to humans—cases of the failure of euthenic experiments—may be cited by way of illustration. A well-known case is that of the "Zero" family residing in Switzerland, and established by the marriage of two vicious and degenerate persons several generations back. The descendants of this pair include hundreds of offspring (of which 190 were known to be living in 1905) characterized by "vagabondage, thievery, drunkenness, mental and physical defect and immorality." But what interests us in this connection is that in 1861 a euthenic attempt was made to save many of these children. These were placed in good families, where they were free from their vicious environment; but "the attempt failed utterly, for every one of the 'Zero' children either ran away or was enticed away by his relatives." More recently a similar experiment has, according to Mudge,[3] been tried in Scotland, where pauper children from Glasgow were boarded out among the respectable and industrious natives of the western coast. Far from producing felicitous results, he has found that these children, for the most part, revert to their inborn tendencies and as a result in these formerly quiet villages a rowdy, irresponsible and even criminal element has been introduced, and "*a new slum area is being created* by the operation of the inherent slum instincts of the putatively rescued denizens of Glasgow's slums." That one of the further dangers incident to this method of caring for dependent children is coming to be realized may be inferred from a recent newspaper report that the Department of Minor Wards of the State Board of Charity of Massachusetts has decreed that none of its foundlings shall be placed in a family in which there is a minor of the opposite sex. "There would be just enough difference in the relationship between the two to make a romance the most probable thing in the world," and this is apparently conceded to be undesirable.

If we accept this conclusion you may ask, Have we not already put the euthenist to rout? Since euthenics depends upon the betterment of

[3] *Mendel Journal*, No. 2, 1911, p. 112, *et seq.*

the race by improving the environment and we know that effects of an improved environment are not inherited, how have we left the euthenist a leg to stand upon? The question seems to be one too simple to need discussion. But it is not so simple. Even granting the non-inheritance of acquired characters, the proper place of environment in a eugenic program is not a simple question. In the first place, it is very difficult to separate out those characters which are the results of inborn determinants (inherited) from those which are produced solely by reaction to environment. Or it may be, as is probably usually the case, that both influences are at work in the expression of the same character. Size may be cited as an example. Undoubtedly a child inherits the tendency to acquire a particular size; but whether it fails to reach this size or exceeds it, is in large part dependent on environmental factors which influence growth, such as food-supply, fresh air, exercise and undoubtedly many others.

But it may be, and has been, asked, granting in full the part played by heredity, is it not possible that a *permanent environment* may be created of such a nature that the outcome will be the same whatever the hereditary nature of the individual? Undoubtedly such may be true in certain restricted cases. For example, if a mosquitoless environment could be established and maintained, what would it matter whether we individually possessed or lacked a natural (inherited) susceptibility to malaria and yellow fever? It is also possible that as the skill of the surgeon and the ingenuity of the bacteriologist increase, we shall be able by means of the injection of antitoxin and the removal or replacement of organs to disregard the inheritance of many diatheses and bodily imperfections. This would require, however, the maintenance of a highly "artificial" environment, and the resulting picture is not one which appeals to us as our ideal type of mankind. It will require much further study to teach us in how far such a condition of affairs may be desirable, and only the future can show how much it may be a necessary result of the multifarious interacting forces of evolution.

Moreover, the cases of this nature must be relatively few—in the great majority, as has just been pointed out, the environment can act only when the necessary hereditary basis is present. We should predict poor success to the stockman who depended entirely upon feeding and care to produce the maximum of marketable beef, or the dairyman who by these means alone expected to compete with herds of selected animals in the production of milk.

Inherent quality is what determines the value of a gem; grinding and polishing only serve to bring out its luster and brilliance, and no amount of labor expended by the lapidary can convert a piece of quartz into a diamond. Selection of specimens which have the inherent qualities is the essential. The breeder knows this, and he realizes the im-

portance of continued selection if he would keep his stock up to standard. His motto is: "Breed only from the best." Is not selection an equally important matter in the evolution of the human race? And are we concerning ourselves sufficiently with the question of whether it is being made, and in the right direction?

There are those who claim that if unhampered the "natural" forces will make such selection and will direct evolution along the proper lines. They argue that the very defects of the pauper, the criminal, the mentally defective and otherwise degenerate classes render them relatively "unfit" for survival in the long run, so that they tend of their very nature to become extinct; and they consider as pernicious any attempt upon the part of society to better the condition of these unfortunates—for unfortunate they are, since they are not themselves responsible for having come into the world with a bad inheritance. But if we mean by "natural" forces and "natural selection" the part nature plays uninfluenced by the hand of intelligent man, why should we leave the evolution of mankind to its slow and uncertain action, when we have found it to advantage to do otherwise with our domesticated plants and animals? If the breeder has born in his herd a sickly or abnormal or otherwise undesirable animal, he does not trust to its dying of "natural" means, but his intelligence comes into play and he takes means at once to eliminate it from his breeding stock. It may, in fact, be of great service to him while it lives, as the ox, or its carcass may be of value when it is killed, as a steer; but he is careful that its blood shall not enter into the future generations of his herd. Is it not desirable, and necessary, that we should employ equal intelligence to the development of the human species that we do to our domestic animals? We shall have to utilize special methods of elimination of the undesirable, but the general problem is the same.

What has been said serves to indicate the prime importance of giving thought to the hereditary factor in human betterment rather than trusting to a blind faith in the establishment of an environmental Utopia. The fundamental error in pampering and preserving the defective and the criminal in order that he may produce more of his kind, which shall in turn increase the drag on human progress, has been pointed out so often and so well that more need not be said at this time. It may be well, however, to turn our attention for a moment to certain special social conditions and institutions in their relation to eugenics. We have in this country a number of special problems which are of the utmost importance to our civic development and well-being. One of these is the race problem; before this is solved, it will be necessary that much more study and thought shall be given to the genetic aspect of the matter. But an even greater menace, to my mind, is that of indiscriminate immigration—for such restrictions as we have on immigration at the present time are entirely inadequate. It is not

immigration of the poor peoples (in the material sense) of other nations, as such, that we need to fear. Many of our best classes of citizenship have come from this type. These are usually the ones who have been our pioneers—they did not come to America merely to find an easier life, but to obtain greater freedom and scope for development. It required a distinct effort on their part to seek new and better conditions under almost certain hardships in a new land; and this very effort marked a virility and fortitude in their make-up which is not manifest in those refugees from justice who seek our shores to escape the consequences of crimes committed or are drifted here along the lines of least resistance. What kind of philanthropist is he who, though he gives his millions to charity (well intentioned but perhaps misdirected) dilutes and contaminates the very structure of our commonwealth by importation of the scum of Europe to enable him to amass the millions? Cheaper labor may be an economic necessity, but can we afford it at the price? The danger would, perhaps, not be quite so great if there were not the possibility of the control of affairs falling ultimately into the hands of these undesirables; but after a short period every man among them is entitled to a vote, and the vote of one man has equal weight with that of another. Furthermore, the political demagogue makes it his business to see that all these votes are polled. Heredity and eugenic principles play no part here; but if suffrage is to be equal, should we not devote our attention to bettering the quality of the voter? With political control in the hands of the inferior, there will be little chance for eugenic legislation.

Of late years several nations have been viewing with alarm their rapidly diminishing birth rates. It has not been generally recognized, however, wherein the danger really lies. The fact of a decreasing population may in itself be of serious economic import; and even though the total population is being maintained or is growing on account of immigration, accession from without then means the swamping of the native stock. But immigration aside, the greatest cause for alarm is revealed upon an analysis of the statistics on the decrease in the number of children born. Such analysis shows that the decrease is not proportional for the total population, but that it is greatest among those classes of society which are the more desirable, namely, the professional classes, the artisans and the so-called middle classes generally. Statistics show that whereas in London the birth rate was higher sixty years ago among the classes just mentioned, fifty years later the conditions had become exactly reversed, and that the paupers, the defectives and the undesirable generally were reproducing at a greater rate than the other civic elements. The outcome of such a state of affairs, without the intervention of other forces, would be easy to predict. One modifying factor exists in the differential death rate, which falls most heavily on the physically and morally unfit; but here

again the statistics have shown that this factor alone is not sufficient as a corrective. Is not this a fertile field for eugenic research? And may the eugenist not hope to offer suggestions of value? It may be some time before we can hope to do much directly to stimulate the birth rate among the better classes, but is it not time steps were taken to check it among the worse?

Economic conditions must be held in considerable part responsible for the decreasing birth rate of the professional and artisan classes. The long period of preparation necessary for a profession and the average comparatively low return, the congestion and complex social relations of our cities, the employment of only unmarried and unencumbered persons in certain positions, such as that of women teachers in many of our schools, the increasing activity of women in affairs which necessitate their continued attention and often take them much from home, laws like the Employers Liability Act, which have "led to discrimination against married persons by large employers of labor with a premium thus put upon non-marriage," and even child labor legislation—these and many other factors of our complicated social conditions have had their effect on the birth rate. It is not my purpose at this time to discuss how this trend of affairs may be arrested or changed. It might perhaps even be argued that upon biological analogy, as the race becomes more specialized and its adaptations more complex, a lower birth rate, accompanied by greater care and preparation given to the offspring, may be a necessity. However this may be, it will be an impossibility if this part of the race allows itself to become swamped in the grim struggle for existence which is ruthlessly going on despite the efforts of many well-intentioned people to stop its progress.

While our survey of the eugenics field has of necessity been very incomplete, I trust I have succeeded in presenting an idea of its diversity and richness. And now let us return for a moment to consider again our relations to our euthenist neighbor. We have seen that we can not expect from the betterment of the environment alone the Utopia often figured in his prospectus. Must we then, as some maintain, abandon all efforts in that line and let "nature" take its course without euthenic interference? It seems to me rather, that with enlightened direction the two methods may work in harmony; with intelligent cooperation the two fields may be tilled for a common crop and to mutual advantage, and we may live at peace. For environment is the lodestone which distinguishes the pure metal from the dross; it is the sieve which, properly used, will enable us to winnow the chaff and the weed seed from the grain. What we as eugenists wish to make plain is that after the bad has been separated from the good they shall not be mixed together again in the sowing, for verily what ye sow, that shall ye reap.

Of course, many of the obvious defects would be apparent in any environment, but where the reaction of inheritance and environment is subtler this is not true. It is only by "feeding out" that the stockman determines which strains of his cattle most readily lay on flesh; without trying it on the track the horseman has no test of the speed of his horse; and unless the dairyman tests the milk-producing qualities of his cows under the most favorable conditions, he has no true measure for selecting those by which he may expect to improve his herd. The rose may never bloom to perfection if it is too closely crowded by other plants—our best flowers need care and protection, because they are adapted only to a special environment. It may be urged that what we need is the virile plant that will assert itself in any environment; that we need the Lincolns and others who could attain to greatness without the aid of colleges or fellowships. But we can scarcely hope to establish at once a race of Lincolns, and it is as probable that the special environments will be as necessary for the higher types of man as they are for our specialized domesticated plants and animals. It is necessary to consider its reaction to the environment the test of the individual.

When we are able to distinguish the good inheritance from the bad, how shall we proceed to perpetuate the one and to eliminate the other? This is a matter which can be worked out only with care and patience. Measures which would disturb the fundamental relationships of society form no part of the conservative eugenic program. The extent to which certain influences, such as the church and popular belief, have been able to influence marriage in the past, lead us to hope that rational education may have a considerable influence in the future. Selective mating may also play a part, since there is a tendency for a person to select a mate who has in general similar tastes and ideals. I have no statistics at hand, but I am of the impression an investigation of the subject would show, for example, a relatively high correlation between the graduates of colleges who marry college graduates. So much as to the perpetuation of the good. As to the bad, the eugenist can here lay down definite plans, and such in fact are already in operation to some extent in certain states. If society is justified in ridding itself of the criminal, it is certainly justified in taking all precautions that he shall leave no descendants.

Our eugenic program is then first of all patient and persistent accumulation and study of the facts, and in the second place education, or extension—the bringing of those facts home to the people. We must be guarded in our statements and cautious in our proposals, for to raise antagonism over misunderstandings or small disputed points will only delay and impede progress. As eugenists—and we should all be eugenists—we must work patiently, impassionately, scientifically, but keeping ever before us as our guiding star a lofty and righteous ideal.

NEGROES WHO OWNED SLAVES

By CALVIN D. WILSON
GLENDALE, O.

THE story, in its completeness, of the existence previous to the civil war, of a large number of free negro slaveholders in America has become for our generation practically a lost chapter. The fact has been almost forgotten. The full data have never been collected, and probably never will be in an exhaustive way. Much material on this subject has perished through the burning of court houses, state houses and similar depositories of documents. The generations that were familiar with this condition have gone. More than forty daily newspapers passed around from one to another during the summer of 1907 a few crumbs of information on this matter as items of curious news. Editorial comment was tinctured with surprise and in some cases with incredulity. The facts have not only their own kind of interest, but they throw light upon the economic and industrial condition of the free negroes before the emancipation proclamation.

When President Lincoln signed that paper he by the same pen reduced to comparative poverty many colored people who thus lost possession of their bondsmen. Some of these were pure blacks; some were mulattoes; while still others had in them only enough African to class them with that race, according to the social decree that a drop of African blood makes a negro, or as President Booker Washington phrases it, "makes him fall to their pile." Certain of these blacks owned from one to a dozen slaves, while others had in servitude from sixty to a hundred or two hundred men, women and children. These were to be found, at one period or another, in nearly all, if not quite all, the colonies or states where slaves were held. In some counties they were numerous, while in others they were unknown. In certain of the states this condition was at times forbidden by law, but often continued in spite of the law, tolerated or ignored; the laws upon the subject also varied from time to time. In other states, free negroes were given the privilege of being masters by special statute or this liberty was covered by general laws.

Certain of these slaveholders became such by inheritance through white relatives; others by gift; and still others by purchase after the manner of their Caucasian neighbors. In some instances they owned

members of their families, as husbands their wives and children, and in other cases the wives owned husbands and children, and again children owned their parents, in order to protect them or ultimately to set them free; the complicated legislation in regard to free negroes at various times and in various places often made it difficult for a free member of a family to manumit the others; sometimes when so liberated they had to be sent out of their state. A large number were owners of slaves without regard to relationships and held them for service and bought and sold them just as did the white people.

The negroes brought with them from their native land African ideas and customs. They were used from immemorial times to slavery. Many of those brought thence to America had been slaves in their own land. Others had been owners of slaves in Africa. In both cases they were used to slavery. It did not therefore seem to them unnatural for a negro in America to hold his brethren in bondage, when he had become free and able to buy his fellows. William Pitt, the younger, in a speech, April 2, 1792, in the British Parliament, on the abolition of the slave trade, said, "Some evidences say that the Africans are addicted to the practise of gambling; that they even sell their wives and children and ultimately themselves." The black man in America has always been imitative, and his desire to do what the white man did doubtless also influenced him in this matter. Moreover, there were in his country tribal differences and antagonisms which continued to obtain in America; the "Guinea nigger" was looked down on by members of superior tribes, and one of a higher race often felt that a Guinea negro was fit only to serve him.

Free negroes in this country began to own other blacks at a very early period in the history of slavery. As illustrating this fact, there is in the possession of the Connecticut Historical Society at Hartford, Conn., a bill of sale from Samuel Stanton, Stonington, Conn., dated October 6, 1783, to Prince, a free negro, of a slave woman named Binar; on the reverse is a bill of sale from Prince to Isaac Denison, Stonington, August 28, 1785, of the same Binar, a slave. One of the first records in the deed books of St. Augustine, Fla., is that of Joseph Sanchez, a colored carpenter, who sold to Francisco P. Sachez a negro slave for three hundred dollars. Such a servant was sold to a negro in Boston, Mass., November 28, 1724. This bill of sale from Dorcas Marshall to Scipio, free negro man and laborer of Boston, of her servant Margaret is given in full in "The New England Historical and Genealogical Register," in the eighteenth volume, on the seventy-eighth page. Early records of Mobile, Ala., reveal the same state of things in that region. Juan Batista Lusser, in 1797, was one of these negro slaveholders, as were also Julia Vilard, Simon Andry and the house of Forbes.

There is a good deal of human interest to be found in many of the experiences of these colored slaveholders and in their relations with those whom they held in bondage. Rose Petepher, of the neighborhood of New Bern, N. C., was a free colored woman who was married to a slave named Richard Gasken, who had taken the name of his master. He ran away and was in the woods for years, when his wife finally bought him to take possession when she could find him; this change of owners brought him in at once. They lived together for many years afterward, raising many children whom they hired out just as slaves were hired out. Thus they all prospered. Near the town mentioned above, on their own land, some of the grandchildren are now living and doing well.

Judge William Gasken, who owned the man of whom we have just told, was thrice married, one of his wives being a daughter of Colonel McClure, of New Bern. After his death, one of the slaves, Jacob, became the property of Mrs. Gasken. This Jacob's wife was a free woman, and they had a son Jacob, then a young man and free, of course, as the child of a free woman. Aided by his mother's efforts, he managed to purchase his father at a very reasonable price as negroes were then held. All went smoothly for awhile, when young Jacob did not act as his father thought he should and his parent reproved him with fatherly love. Young Jacob was so disgruntled that he went off to a negro speculator named John Gildersleeve, who was from Long Island and was then in New Bern. This trader bought the father at a high price and at once sent him off south. Young Jacob afterward boasted that "the old man had gone to the corn fields about New Orleans where they might learn him some manners."

There was, about 1840, in the county of Mecklenburg, Va., a family of free negroes who owned slaves. Mr. George W. Brooks, of Atlanta, recalls them when he was a youth in North Carolina in the county of Person, which lay immediately on the Virginia line. There was there quite a colony of free negroes, many of them named Epps, and supposed to be descendants of the slaves set free by Mr. Epps, the brother-in-law of Thomas Jefferson. In Person County there was a free negro named Billy Mitchell, an honest man of genial disposition, who being without means, often hired himself to work for Mr. Brook's father on his tobacco farm. Mr. Brooks remembers hearing Mitchell telling his father of his trip to Mecklenburg, about thirty miles away, when and where he went courting, and told of the lands and slaves which were owned by his girl's father. He told with much humor of an incident which occurred while he was there. He went out one morning with the girl's brother to the pig pen to look at the fattening swine. He said that one of the slave boys came and got upon the pen with them; that soon he heard the girl calling her mother to "look at Jim perched up

on the hog pen with the white folks." Billy said that he looked at them all and he could not see but Jim was about as white as any of them. Billy went back and married the girl, took up his abode with them, became interested in the estate and became a slave owner himself.

One John Carruthers Stanley, negro, was born in Craven County, N. C., in 1772. His father was a white man and his mother was an African woman purchased from a northern slave trader in the West Indies, where the woman with other negroes had been carried direct from Africa. Captain Stewart was at the time sailing one of John Wright Stanley's vessels, running between New Bern and the West Indies. In his boyhood the young negro John was apprenticed to a barber, at that time in New Bern, named John Carruthers; J. C. Stanley was generally known as "Barber Jack" toward the end of his life. He married a woman with more negro blood than he possessed, hence she was darker in color than her husband, though he was not light. In the year 1808 his mistress, Mrs. Lydea Stewart, the captain being then dead, had him emancipated by the North Carolina legislature. Then he advanced rapidly in property until he was the owner of sixty-four slaves, and at the same time there were forty-two negroes of both sexes bound to him by law for service. At that time he owned two large plantations a few miles distant from New Bern, one on Trent River called Lion Pasture, one on or near Bachelor's Creek called Hope; on these his negroes were employed. He resided in New Bern and owned houses there. But finally after so much success, he engaged in speculations and went down hill even faster than he had gone up. In the meantime he had reared sons and daughters and had educated them. Some of these children owned slaves up to the civil war, and they held them rigidly to account. Stanley died some years previous to the war. This family had necesarily to move in a circle of their own; yet now and then the women would be invited to dinner by a few of the best citizens. One of the Stanley boys, John Stewart, taught free school in a small way and occasionally clerked in a store. He held slaves, as did his sisters, who never married, up to the emancipation proclamation.

There was a colored brick mason in New Bern named Doncan Montford, who owned slaves; he was a dark mulatto. One of his slaves, Isaac Rue, was also a mason; he sold him to a lawyer, George S. Altmore. Isaac's wife was a free woman, a pure-blooded negress. They had children, who under North Carolina laws were free. One of their grandsons, Edward Richardson, was at one time postmaster of New Bern, appointed to the office by a Republican president.

There was in Columbus, Ga., a free negress named Dilsey Pope who owned a house and lot and also her husband, whom she hired out. He offended her in some way and she sold him to the late Colonel Seaborn

Jones; then she repented and tried to repurchase him, but his white owner now turned the tables by refusing to sell him.

A free negro named Charley Cobb, a carpenter by trade, lived in Montgomery, Ala. Mr. S. Q. Hale, of Birmingham, remembers this man when he was himself at home on his father's plantation on the Carter Hill road, now the property of the descendants of Colonel Arrington. Charley owned a negro named George; he was also owner of a horse. How to make George and the horse self-supporting was the problem that confronted Charley. In attempting to solve this question, Charley rented of Mr. Hale, senior, a field containing fifteen or twenty acres; the rent note was for a money consideration. About nine o'clock on the morning when George began to pitch his crop, he, jug in hand, appeared at the well in Mr. Hale's yard. Here he met one of Mr. Hale's servants, Maum Flora, and it seemed to be a case of love at first sight. Each morning and afternoon throughout the cropping season, George would appear at the well, ostensibly to quench his thirst, and on each of these occasions he and Maum would flirt for an hour or so under the big oak by the well. Meantime Charley was plying his trade in Montgomery, and when the note fell due he asked Mr. Hale, "how much money in addition to all of George's crop would satisfy the claim?" Charley the master had worked for the support of George the slave.

There was a negro named Nat Butler who lived near Aberdeen, Harford County, Md., who owned a small farm and bought and sold negroes for the southern trade. This sharp and noted fellow would persuade a slave to run off and hide for a few days at a place prepared by Butler, who would in the meantime see the master of the runaway and learn the price he would take for him. If the owner had little hope of recovering his slave and so placed the price low, Nat would buy him and resell him to slave dealers who knew Butler's rendezvous for hidden negroes. His conduct became so notorious that he lost the confidence of slave owners and respect of negroes, who several times tried to murder him.

Jim Scott, a worthy colored man of the same county, was a local preacher and an industrious servant. He bought himself, wife and children from his master, Mr. George Amos, giving his own note, endorsed by his white neighbors. He hired out his wife and larger children and himself for ten years and paid off his indebtedness. He offered his son Henry to Mr. Henry Webster of "Webster's Forest" for three hundred dollars for five years, or until he was twenty-five years of age. Another negro in the same region sold his children in order to purchase his wife and set her free.

Dick Hunter, of Laurens County, S. C., was the slave of his wife, and he finished paying for himself long after the civil war. He died

in 1902. Dick was first owned by Mr. James Hunter. The master entered into an arrangement with the boy, an intelligent youth, by which the latter was permitted to work for others for wages and reserve a part of his earnings to be applied to the purchase of his freedom, one thousand dollars being the stipulated price. Dick married a woman of color, and had paid six hundred dollars of his purchase money when his master died intestate, leaving no record of his private arrangement with the slave boy. Thereupon Dick was sold as one of the properties of the estate and was bought by a bachelor named Nugent. Meanwhile Dick's wife had died and he married another free woman of color. This woman purchased her husband from Nugent, agreeing to pay for him on the installment plan. During four or five years the installments were paid, amounting to several hundred dollars. Then the civil war broke out, and in a little while Nugent died. His estate was claimed by relatives who lived in the west, and contracts between masters and slaves for the manumission of the latter were at that time frowned upon by the law. Dick was put upon the block and sold for the second time, bringing fifteen hundred dollars. The buyer was again his wife and she was enabled to make the purchase through the generosity and compassion of a white neighbor, Mr. Clark Templeton, who provided the money. When the war ended this debt was still due Templeton's estate, and Dick did not repudiate it, though doubtless under the law he might have done so. On the other hand, he continued to work and save, and in the course of six or eight years after emancipation he paid the last dollar with interest.

Aunt Fanny Canady was a colored woman of Louisville, Ky., who bought herself and several members of her family. She also owned her husband, named Jim, a little drunken cobbler. One day Fanny went into her husband's shop with fire in her eyes and finger pointed at her husband. She said, "Jim, if you don't 'have yourself, I'm gwine sell you down river." Jim sat mute and trembling, as to send down the river meant to sell to a negro trader and to be taken to the cotton fields of the far south.

At the outbreak of the civil war there was in Norfolk, Va., an industrious negress who was a huckstress in the market and owned her husband. He was an ardent secessionist and was in full sympathy with the firing on Fort Sumter. After Norfolk was evacuated and was occupied by the federal forces, he was loud in his expression of southern views and was at one time in the chain gang because of opinions obnoxious to the military. No slave trader was ever more convinced that the negroes were made for slavery.

A colored man named Dubroca, who lived until 1906 near Mobile, Ala., had been the owner of numerous slaves. Not long before his death a white acquaintance met him on the streets and asked him how

he felt. He replied: "O, I am feeling poorly. I am getting old. They all tell me it was a good thing to free the negroes, but I wish I had my 'niggers' back once more."

There were instances in which free negroes became the purchasers and masters of transported white people, redemptioners. An example of the purchase by free negroes of two families of Germans who had not been able to pay their passage from Amsterdam to Baltimore and were sold for their passage money to a term of labor, is given in a volume issued in 1818 in Stuttgart. It contains letters written in 1817 addressed from Baltimore to the Baron von Gagern, Minister Plenipotentiary to the diet in Frankfort-on-the-Main. The Germans of Baltimore were so outraged by this action that they immediately got together a purse and bought the freedom of these immigrants. An early law of Virginia is aimed at the same thing, and forbids negroes or Indians to buy "Christian servants," but permits them to purchase those of their own "nation."

A colored man now living in Pensacola, Fla., by name John Pous, is the son of a white father and a negro mother. They owned many slaves. When the father died the family continued to own them until the civil war. John fought in the union army. Some of his slaves are with him yet—to be supported by him.

One free negro in North Carolina became the purchaser though not the owner of his family. The circumstances were touching. He was a blacksmith and had married a slave woman, by whom he had several children. His shop was on his former master's farm, where he was liked and kindly treated. But finally this man got involved in debt and all his slaves, among them the blacksmith's family, were seized by the creditors and sold to a speculator, who resold them in Mississippi. The husband went desperately to work and in a few years got together sufficient money, placed it in their first owner's hand and got him to repurchase and bring back from the terrible south the loved ones; he was content that they should remain slaves—for the temper of the neighborhood was at the time hostile to manumission—so that he need not be separated from them.

There are other sources of information on this theme than personal reminiscences, though certain of these are difficult of access. If, for instance, all of the census of the United States for 1790 were in print, doubtless a very large number of data of this kind could be obtained. The census of only three states, New Hampshire, Vermont and Maryland, has been printed. That of Maryland furnishes interesting facts concerning negro slaveholders. In the volume called "Heads of Families, First Census of the United States; 1790; State of Maryland," issued by the government in 1907, the white and black population is given by counties. The report indicates in different columns free white

males of sixteen and upward, including heads of families; free white males under sixteen; free white females who are heads of families; all other free persons; and slaves. In the lists of names, the free negroes and mulattoes are always distinguished from white persons. Therefore in studying this census it is a simple matter to ascertain the number of free negro slaveholders reported and the number of their slaves.

In this census we find that there were in Maryland in 1790 forty-eight free negro slaveholders, owning one hundred and forty-three slaves. It is probable that the number of slaves was somewhat larger, since in several instances the figures in the slave column are illegible in the original manuscripts of the census; in the printed volume these illegible figures are marked as such by a star; when a star is found in a column set apart for slaves, this must mean that there was at least one slave held by the person whose name is opposite the star; we have in such cases counted one slave. In passing, it is curious to note that in this first census we find in Charles County, Md., in 1790, one Eleanor Linkin, mulatto, had in her household three free persons and two slaves; if this Eleanor were not dated 1790, or some other early year, she would certainly have been thought one of the many namesakes of the great emancipator.

The "List of the Taxpayers of the City of Charleston, S. C., 1860," names one hundred and thirty-two colored people who paid taxes on three hundred and ninety slaves in Charleston. In this class were included eleven Indian families who had consorted with the negroes. In or near Charleston "free colored people," as they were there known, were generally of mixed blood, sometimes of Caucasian and African and sometimes of Caucasian and Indian. They obtained slaves by inheritance, by gift and by purchase. Some of these slaveholders were children of rich planters; they were not considered illegitimate or slaves, but as children and were educated and bore the name of the father. Upon the death of the father, these children would come into possession of his estate, including slaves.

There was a rich planter in Charleston named Fowler who took a woman of African descent and established her in his home. It is not recorded whether or not he married her, but be had no other family. There was a daughter born, who was called Isabella; the planter insisted that she should be known as Miss Fowler. She grew to womanhood and was married to Richard De Reef, a young man of Caucasian Indian blood. Her father gave her a wedding gift of a plantation and enough slaves to work it. At emancipation Mrs. De Reef had forty slaves liberated. In Charleston in 1846 there was a free woman of color whose father had been her master and who manumitted all of his children. She bought a slave for several hundreds of dollars; she was satisfied with her bargain and in a short time they were married.

We have found a large number of individual instances of negro slaveholders in Kentucky, Tennessee, Virginia, Maryland, both the Carolinas, Missouri, Georgia, Alabama, Florida, the District of Columbia, Delaware, Mississippi and Louisiana, but have not space for all of these in this paper. We will, however, give a few of these.

Mr. Thomas Blackwell, who lived in Vance County, N. C., owned a favorite negro named Tom, who was a fine blacksmith. He was allowed to hire his own time and was finally permitted to buy his freedom at a price far below his worth; he was a very valuable man. This was about 1820. Tom prospered and bought two or three slaves. William Chavers was a well-educated negro who bought a good deal of land in Vance County, from 1750 to 1780, and he owned a good many slaves; his descendants also for several generations were slaveholders. John Sampson, of Wilmington, was a slaveholder in 1855.

Robert Gunnell, a free-born, full-blooded African Virginian, married a slave wife, but bought her of her master before their first child was born, so becoming the legal owner of her and all her children and of their daughter's children. He, with all his family, was a resident of the District of Columbia, during the civil war, when slavery in the district was abolished. All slave owners there received compensation for each slave. Gunnell received three hundred dollars each for his wife, for each of his children and for all the living children of his daughter—eighteen in all. Except for a short time during the civil war he lived at Langley, Fairfax County, Va., and died there in 1874. Also, in the District of Columbia, Sophia Browning bought her husband's freedom for four hundred dollars, from the proceeds of her market garden, and she was in turn purchased by him. Alethia Tanner purchased her own freedom in 1818, for fourteen hundred dollars and that of her sister Laurena Cook and five children, in 1826. At the emancipation in the district, April 16, 1862, one negro received $2,168 for ten slaves; another $832 for two; another $43.80 for one, and another $547.50 for one, while from the $4,073 placed to the credit of the Sisters of the Visitation of Georgetown, $298.75 was deducted by Ignatius Tighlman toward the purchase of the freedom of his family.

Among the people with negro blood in the Indian Territory there were slaveholders. It is well known that the Five Civilized Tribes of the Indian Territory—Creeks, Cherokees, Chickasaws, Seminoles and Choctaws—had slaves both before and after establishing their new nations in the west. Among the Creeks and Seminoles the lines between masters and slaves were less rigid. There has been a good deal of intermarrying between these tribes and negroes. There three-quarter blood makes an Indian, though the other quarter is negro; in recent allotments, the United States government adopted this per cent. in determining who were freedmen and who were Indians. Three of the

tribes never recognized the right of intermarriage with the negro. The present chief or governor of the Creeks held slaves and is part negro. One official of the Creek tribe, who had sufficient negro in his family to exclude his children from the public schools of the nation under its laws and sent his children abroad to be educated, held slaves.

The most familiar aspect of this subject is that which existed in Louisiana. In "The Cotton Kingdom," by F. L. Olmsted, he says:

He said—a negro with whom the author was talking in that region—in answer to further inquiries, that there were many free negroes all about this region. Some were very rich. He pointed out to me three plantations, within twenty miles, owned by colored men. These bought black folks, he said, and had servants of their own. They were very bad masters, very hard and cruel—hadn't any feeling. "You might think, master, dat dey would be good to dar own nation; but dey is not. I will tell you de truth, massa; I know I'se got to answer; and it's a fact, dey is very bad masters, sar. I'd rather be a servant to any man in de world, dan to a brack man. If I was sold to a brack man, I'd drown myself. I would dat—I'd drown myself, dough I shouldn't like to do dat nudder; but I wouldn't be sold to a colored master for anyting."

In "A Journey in the Seaboard Slave States," by the same writer, he says:

There are also, in the vicinity, a large number of free colored planters. In going down Cane River, the *Dalmau* called at several of their plantations, to take on cotton, and the captain told me that in fifteen miles of a well-settled and cultivated country, on the bank of the river, beginning ten miles below Natchitoches, he did not know but one pure-blooded white man. The plantations appeared no way different from the generality of those of the white Creoles; and on some of them were large, handsome and comfortable houses. These free colored people are all descended from the progeny of old French or Spanish planters and their negro slaves. Such a progeny, born before Louisiana was annexed to the United States, and the descendants of it, are entitled to freedom.

An intelligent man, whom I met at Washington, who had been travelling most of the time for two years, in the planting districts of Louisiana, having business with planters, told me the free negroes of the state in general, so far as he had observed, were just equal in all respects to the white creoles. There are many opulent, intelligent and educated. The best houses and most tasteful grounds that he had visited in the state belong to a nearly full-blooded negro—a very dark man. He and his family are well educated, and though French is their habitual tongue they speak English with freedom, and one of them with much more elegance than most liberally educated whites in the south. They had a private tutor in their family.

The following paragraphs are copied from a footnote to an article on "Condition of the Free Colored People in the United States" in the *Christian Examiner* for March, 1859:

"A Wealthy Negro Family.—An immense estate in Louisiana, embracing over four thousand acres of land, with two hundred and fifty negroes belonging to the plantation was recently sold for a quarter of a million of dollars. The purchaser was a free negro, who is said to be one of the wealthiest men of the South."

The above is from a New York paper, and refers to the Harrison property, which was purchased by Cyprian Ricaud, a free man of color of our parish. If the property had contained as many acres as stated above and as many slaves, it would have brought nearer a million and a quarter than a quarter of a million. On the contrary, the land, we believe, comprised some sixteen hundred acres, and there were about one hundred slaves of all sizes. It lies in the rear of Madame C. Ricaud's plantation; and the two plantations, now owned by that family, probably do comprise the number of acres of land and slaves as above stated, making them, doubtless, the richest black family in this or any other country.[1]

We shall now attempt to make an estimate of the number of negro slaveholders throughout the period of the existence of slavery in America, and the number of slaves held by them. We shall proceed upon the basis of certain data already ascertained and set forth in this paper.

Let us take first the date 1790. In that year there were in Maryland forty-eight negro slaveholders, owning one hundred and forty-three slaves.

There were then in that state free negroes, 8,043. The ratio of negro slaveholders there and then to other free negroes in 1790 in Maryland was 1 in 167. The average of slaves per owner was 3.

There were in 1836 in New Orleans 640 slaves owned by free negroes. The average of slaves per negro owner in Maryland was, as we have shown, 3. Taking the same average as holding in New Orleans in relation to these 640 slaves, we have 213 colored slave owners in New Orleans in 1836. We may safely assume that there were as many more in the whole state of Louisiana, or 426 in all, at that date.

There were in Louisiana in 1830 (we have the census by decades, and not for the years between), free negroes, 16,710. The ratio of the 426 colored slave owners to other free negroes would be 1 in 39.

Again, in Charleston, S. C., there were in 1860 colored slave owners, 132. We may safely assume that there were as many more in the whole state of South Carolina, or 264 in all.

In 1860 there were in South Carolina free colored people, 9,914. The ratio is 1 to every 37 other free colored people in that state at that time.

There were in the slaveholding states during the whole period of slavery at least 500,000 free negroes. This can be estimated by taking the total census of free negroes, by decades, from 1790 to 1860, dividing in half to avoid counting any one twice, and dividing again in half to exclude the free states.

Taking the ratio 1 in 167 in 1790 in Maryland, and 1 in 39 in Louisiana in 1836, and 1 in 37 in South Carolina in 1860, and taking their sum and dividing by 3, we have the ratio of 1 in 80 as a slave

[1] Extract from the Plaquemine, La., *Sentinel*, 1859.

owner. Applying this ratio to the 500,000 free negroes, we have 6,200 negro slave owners.

Accepting the proportion of slaves to each owner, as found already, 3 each, we have more than 18,000 slaves held by negroes in the course of slavery in this country.

We believe this to be a very moderate estimate. We are of the opinion that these figures are much below the fact. Yet they may be suggestive as a conservative estimate on a matter concerning which no estimate has ever been made before, so far as we know.

This puzzling subject has interested me for a number of years. Several years ago, I gathered such data as I could at the time and prepared a paper on "Black Masters," which appeared in the *North American Review*, November, 1905. Later, I undertook a further search. I searched as much of the literature of slavery as was accessible to me, and this was done to a major extent with only negative results. I carried on a wide correspondence with state librarians, public librarians, historians, historical societies and a host of individuals who might probably be possessed of some of the knowledge I was seeking. I sent cards to twenty newspapers asking for correspondence on the subject. These letters in two conspicuous instances came to the notice of leading newspapers, which took up the subject and printed letters, quoted documents and brought out a good deal of illuminating information. During the summer of 1907 more than forty newspapers quoted these data or commented on them, in the main giving the few facts over again as they had appeared in the two or three papers that opened up the discussion. This was spoken of as "the new phase of slavery," and was discussed editorially in several instances. Certain editors frankly acknowledge previous ignorance of such a condition. Others lifted their eyebrows and suggested a degree of incredulity, perhaps scenting a fake. A number of journals, however, brought some grist of desired information to the mill.

The bibliography of this subject is exceedingly sparse. There is no treatise specifically on the theme, except my own paper in the *North American Review*. There is no reference to it in any encyclopedia, as far as I can learn. There are only scattered references to it in a few books and in files of newspapers. The bulk of the facts is still buried in unpublished documents in court houses, historical societies and libraries. There are probably a few hundreds of people still living who have recollections of this phase of slavery. So we are justified in calling this subject, in its completeness, a lost chapter.[2]

[2] The facts for this essay were gathered by me for Mr. A. H. Stone, representing the Carnegie Institution of Washington, and are here used by his consent.

THE ADMINISTRATIVE PERIL IN EDUCATION

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PRIVILEGES must be justified by occasion. The close of an academic service of twenty-five years is the justification; the privilege assumed is an indulgence in the use of the imperious pronoun, first person singular—a considerable liberty of expression, as it substitutes conviction for argument. In extenuation I plead that I am not speaking for myself, but, under the warrant of sympathy, for an unorganized, probably unorganizable, group, scattered geographically, exposed to varied intellectual climates, united by a community of interests, reacting similarly to common factors in experience. The only singularity is a persistent concern for my professional class—a profitless solicitude for their welfare.

Looking backward I distinguish overlapping periods of development in the higher education, of divergent tendency; nor is this a gray-haired retrospect. Things move quickly in a country where each generation undertakes to make precedents, and an imitative subserviency follows the flag of heralded success. I began my career under the impulse of a quickened interest in intellectual callings, for which at the time the Johns Hopkins University was the progressive sponsor. The spirit of the movement was the emphasis upon the personality and training of those who were and were to be intellectual leaders. I found myself in an intensely alert democracy of learning. The feeling was in the air that notable men were there doing notable work; prophets were honored in their own land, the honor often echoed from abroad. My most salient impression of President Gilman was and remains that of a man with keen joy and pride in the discovery of unusual men, in facilitating their emergence, in proclaiming their achievements. Rank counted for little and quality for much.

The ambitious colleges were changing to universities, sometimes prematurely with flourishes on paper unsupported by performance; generally with a sincerity of spirit and policy. Men of my academic generation felt themselves part of this progressive movement. They gained a foothold, and, as a rule, rapid advancement. They were called upon to occupy responsible if elastic chairs, the bright prospects offsetting the shortcomings of the moment. The Ph.D.'s of the 80's and early 90's felt themselves a welcome part of the university with whose fortunes they linked their own, were themselves contributors to its growth with a reasonable singleness of purpose and sensible community of endeavor. Quite naturally their engrossment in establishing their positions kept them away from intimate concern with general

policies and problems of management. Faculties were small and informal; the calls of committees not oppressive; problems of adjustment relatively simple; rival interests were not yet disturbing. It was not a golden age; nor is its color-scheme in memory due to the mellowing of years. There was an abundance of homelier metal; and the process of refinement was uncertain and tedious. Yet there was an orchestral harmony—a sense of being considered and of playing a part—that can not be referred to an insensibility to discord, or to a blissful ignorance of standards and possibilities.

The period of transition came with a rush and was hurried to its consummation. Everything grew, enlarged, expanded—grounds, buildings, plans, facilities, positions, students and duties—most of all students and duties, least of all salaries. Some of the maturer members of the guild felt the change as delayed growing pains. The adjustment involved difficulties and a stern disregard for hesitation, a brusque treatment of opposition. Size was truly a complication that must be fairly met. Competition without and rivalry within became conspicuous; the perspective of things changed notably. Administration became imperative. Correlation was urgently demanded and unflinchingly enforced. Standards and ideals were changing; whether for good or ill was far more uncertain. The success of measures became more momentous than the manner of securing them. Interests of an academic type were confronted with interests of a measurably different temper, and with the assertion of authority. Pressure from the outside, from legislatures in state universities, from alumni and the public in all, became differently insistent; dissensions complicated issues. The administration which under older conditions had stood between the board and the professor's security, came to carry the external pressure to the academic career. The professor was diverted by manifold cares beyond the class-room or laboratory or study; and found that his availability for the purpose of organization directly affected his influence, his value, preferment, his status. Academic peace became as obsolete as the cloister; privileges of one order were sacrificed for advantages of another that quite too commonly failed to appear.

And now I may find relief in the use of the present tense. It is of the actual situation and of the recent past that I speak, and that without reticence. This is not a testamentary nor yet an elegiac occasion, and by the same token not an apologetic one. I have indicated the conditions under which certain convictions have matured, slowly and confidently—convictions that carry a vital message of caution, of distrust. The one paramount danger, the most comprehensively unfavorable factor affecting ominously the prospects of the higher education—and the lower not less so,[1] though differently—is *the undue dominance of ad-*

[1] The danger of externalism—the theme of the present discourse—to the public school-system is looked upon by Mr. J. F. Munroe ("New Demands in

ministration: in policy, in measures, in personal relations, in all the distinctive interests of education, and the welfare of ideas and ideals. What is imperiled most directly is the academic career: its worth, its service, its security, its satisfactions, its attractiveness to the higher types of men.

The professorial career is in its requirements distinctive, though not unique; it is by nature institutionalized. The professor can not very well be unattached or very much of a free lance; yet his creative energies demand a sympathetic, unhampered environment. He can not sell his birthright and remain a freeman; the institution can not place a mortgage upon his output without injury to its value. The university can best provide the collective facilities, the communal stimulus, the larger environment, in which intellectual products flourish. Institutionalism carries a menace to personality, at the worst reducing those enlisted in its service to a set of cogs in a wheel; yet the intimate association with a corporate body offers a worthy communion if worthily administered by those free to follow the wisdom that in them lies. The corporate university can be no more and should be no less than the reflex of its spirit; to express the quality we borrow the term *esprit de corps*—the indigenous sentiment holding that corporations have no souls. Under present conditions it is a needlessly difficult task to make the inevitable institutional quality of the professorial service a source of strength; to reduce its disabilities is the first step. American professors are not disposed to call one another "Herr College"; what he professes shapes the manner of the man above the bare fact of his profession; and thus the professor loses the solidarity of interest more readily attained in other callings. His professional sense needs stimulation. The requisites of a true profession are that its members shall authoritatively represent, advance and control its interests, as well as the qualifications for membership; each member thereof shall be subject definitively to the judgment of his peers. The profession forms a peerage in the best sense. Thus weighed, the professoriate is found sadly wanting; and until this privilege is restored or acquired for the American professor, the career must continue to suffer a serious, almost a fatal handicap. Present tendencies are aggravating this unfortunate influence; the current is set strongly in the opposite direction;

Education, 1912'') as a potent factor in the comprehensively unsatisfactory character of our educational system, methods and product. He regards the limitation of the authority of school boards and the establishment of school faculties with authority over educational matters as essential steps to permanent improvement. The present system wastes the intellectual force and enthusiasm of good teachers; it deadens initiative and cultivates prudent acquiescence. In its place a true professionalism would advance the status of teaching and teachers more effectively than any other single measure, and would bring with it the benefits now sought for in vain by petition and complaint.

its drift is felt by those in the stream and by the onlooker alike, as the sweeping *dominance of administration.* That temper controls the professorial career, thwarts its development as an independent life-service. The formula of the investiture of the scholar, "with all the dignities and privileges thereunto appertaining," has come to carry a cynical flavor—the privileges often enjoyed as one is said to enjoy bad health.

The prevalent system of university control has been called "externalism." Authority rests ultimately and so far as they choose to exert it, constantly with the governing boards of trustees or regents; it rests dominantly, and by delegation from the former, with the president, intermediately at the latter's discretion with the deans. Let it be conceded that a system often yields to, but yet more constantly determines, or reflects, the spirit of its administration. But as to the nature and effect of the system, I propose to cite others; it would indeed be strange if my conviction of so public a situation should not be shared by kindred observers. To reflect the distrustful and anxious attitude of thoughtful critics, I shall present a considerable series of views touching upon all sides of the situation. I must rely upon the earnestness of expression and the cumulative appeal to carry the full force of the protest, which is necessarily weakened by detachment from the supporting context.

The contrast of the prevailing "American" system with the practise and spirit of other countries is striking. In our allegedly democratic land "university government has assumed a form that we might have expected to see in a land accustomed to kings. European universities have a constitution that might have come from some American political theorist: American universities are as though founded and fostered in the bourne of aristocracy. . . . The polity that we might call monarchic is thus not only frequent in the new-world colleges, but it is stripping away the few lorn shreds of popular control which still remain among them" (G. M. Stratton). "Elsewhere throughout the world the university is a republic of scholars, administered by them. Here it is a business corporation" (Popular Science Monthly: editorial). It is indeed a "departure from our usual American ideas as well as from the scholarly custom elsewhere, that we should have called into existence in affairs of learning a regnant body the life activities of whose members lie outside the realm they rule" (G. M. Stratton). "The American university has become an autocracy, wholly foreign in spirit and plan to our political ideals and little short of amazing to those marvels of thoroughgoing democracy, the German universities" (J. P. Munroe). "The main ends of the university are the same in all lands, but our American presidents and boards of trustees are an indigenous product which can scarcely be regarded as essential" (J. McK. Cattell). In brief it seems that in our superficial democratic zeal we react aggressively to the show of authority and the symbol of distinction,

while quite insensitive to the inner thralldom covered by specious profession. Our English exemplars accept the former naturally, gauging it at its true worth, and keenly resent any invasion of the spirit of liberty; there "the university is unconstrained in presence of its visible lord, bringing as he does, no thought of imposition, but standing forth rather as the representative and spokesman by free choice of those who are the learned guild" (G. M. Stratton). In other relations, also (witness: politics), our citizen plainness may harbor the vested interests of autocracy.

We may not be deeply concerned as to the source of this American brand of externalism, though such knowledge may temper without removing our conviction of its present unsuitableness. It has been suggested that it is a sympathetic survival of a colonial, absentee form of government—"a government that was well enough for a boy's academy in colonial times" (G. M. Stratton); also, that "the present relationship between the faculty, trustees, and president may be regarded as a haphazard growth, the result of a *laissez-faire* policy, affording an example of the same sufficient-to-the-day spirit and smug satisfaction" (Stewart Paton) that obtains in municipal management, in which in turn we acknowledge old-world superiority. The unsuitability of the system to needs and conditions, and the menace it harbors to interests of vital import remain the same, whatever the historical justification, or lack of it. Freely and fully admitting its points of merit, the most charitable verdict may still recognize it as an example of the partially good forming a serious obstacle to the better or the best. "The administration imposed on universities, colleges, and school systems is not needed by them, but simply represents an inconsiderate carrying over of methods current in commerce and politics" (J. McK. Cattell). "The development of our American universities is seriously handicapped by the present system of administration" (Stewart Paton). "No single thing has done more harm in higher education in America during the past quarter-century than the steady aggrandizement of the presidential office and the modelling of university administration upon the methods and ideals of the factory and the department store" (*Springfield Republican:* editorial). "The very idea of a university as the home of independent scholars has been obscured by the present system" (J. E. Creighton). "All experience of democracy with itself justifies the plea for more democracy in American educational administration" (*Boston Herald:* editorial). The disastrous effect of the system in blighting the academic career is set forth in no uncertain terms. "It is one of the most productive of the several causes which are working together to bring about 'the degradation of the professorial office'" (G. T. Ladd). "If the proper status of the faculties is to be restored, and if the proper standard of educational efficiency is to be regained, there must be a radical change in the

relations of the teaching and corporate boards" (J. J. Stevenson). "Unless American college teachers can be assured that they are no longer to be looked upon as mere employees paid to do the bidding of men who, however courteous or however eminent, have not the faculty's professional knowledge of the complicated problems of education, our universities will suffer increasingly from a dearth of strong men, and teaching will remain outside the pale of the really learned professions. The problem is not one of wages; for no university can become rich enough to buy the independence of any man who is really worth purchasing" (J. P. Munroe). The prevailing system "does not attract strong men to the profession of teaching, nor does it foster a vigorous intellectual life in the universities. And occasionally a gross and tyrranical abuse of authority reminds the world how far America is behind Germany in the freedom of its university life" (*Springfield Republican:* editorial).

It is quite proper that the professor should be called to account for his meek submission to the situation that is oppressively thrust upon him. "Now the idea of professionalism lies at the very core of educational endeavor, and whoever engages in intellectual work fails of his purpose in just so far as he fails to assert the inherent prerogatives of his calling. He became a hireling in fact, if not in name, when he suffers, unprotesting, the deprivation of all initiative, and contentedly plays the part of a cog in a mechanism whose motions are all controlled from without" (*Dial:* editorial). "Young men of power and ambition scorn what should be reckoned the noblest of professions, not because that profession condemns them to poverty, but because it dooms them to a sort of servitude" (J. P. Munroe). "But there is real danger that the existing system may prove repulsive to men of the highest intelligence and character and that mediocrity and time-serving may be developed where we need the most vigorous ability and independence" (POPULAR SCIENCE MONTHLY: editorial). "The degrading tenure" of the professor is spoken of as forming a "nursery of abject cowardice" (W. C. Lawton). How oppositely the protest of the professor is met when the academician summons courage enough to protest, appears in these two comments: "Truly the academic animal is a queer beast. If he can not have something at which he can growl and snarl, he will growl and snarl at nothing at all" (*Educational Review:* editorial). "At any rate American professors have come to feel that their independence is imperilled and their proper influence in the university organization seriously impaired by the activities of deans, presidents, and trustees." "Whatever organization may be necessary in a modern American university, the institution will not permanently succeed unless the faculty as a group of independent personalities practically control its operation" (J G. Schurman). And here the call to arms! "The professor must teach the nation to respect learn-

ing; he must make the nation understand the functions and the rights of the learned classes. He must do this through a willingness to speak and fight for himself" (J. J. Chapman).

The system is concentrated in the president. So often uncritically the recipient of praise as the visible embodiment of the source from whom all blessings flow, he is as naturally chosen as the one on whom all curses fall. Critically temperate statements admit the enormous powers he wields to mitigate or to aggravate the evils of the system; yet we are asked to consider that "the benevolent and efficient despot is the worst kind; the cruel and incompetent despot soon disappears" (J. McK. Cattell). The educational situation is naturally subject to the unfortunate influences of the social climate. "The individual has once more been subordinated, crudely commercial standards prevail, and control has been seized by the strong and the unscrupulous" (J. McK. Cattell). The relation between the president and the professor, though not untouched by the quality of mercy, is indeed strained, quite too commonly to the breaking-point. Its vital wrong is this: it sets forth that "we exalt administrative ability above scientific insight." Universities "should be the last to typify in their own structure the thought that discovering truth and imparting the vital principle whereby others may discover it are of a dignity less than that of organizing and management" (G. M. Stratton). This is the charge; that the president "is in large measure thought of, and thinks of himself, as the master, or the foreman, or the captain, of a body of men working under his direction; and this fact has a potent influence on the whole character and spirit of academic life in America" (*New York Evening Post:* editorial). Presidential inaugural addresses show the drift of the current: "And there is the style of ill-concealed arrogance, expressing the personality of the man who frankly thinks of his colleagues as subordinates, and who will ride rough-shod over their rights as men and their freedom as educators whenever his masterful instincts prompt him so to do" (*Dial:* editorial). The president is appointed "not to elevate the institution as an educational power, but to make of it 'a big thing.' . . . The executive duties of his office render the president less and less fitted as the years go by to represent the purely educational side of the institution, yet every year strengthens his control of all the interests. This condition is not in accord with business common-sense" (J. J. Stevenson). The universities seem to drift towards or to desire "high-priced imperious management" and "low-priced docile labor" (*Dial:* editorial)—truly a dismal combination. The censure is at times diverted to the governing board. "Our colleges have been handled by men whose ideals were as remote from scholarship as the ideals of the New York theater managers are remote from poetry. In the meanwhile the scholars have been dumb and reticent" (J. J. Chapman). And this in extenuation: "The financial gentlemen are applying in

naïve good faith, to a mechanism which they utterly fail to understand, the rules for efficiency in a bank or a department-store" (W. C. Lawton). They seem to be as unfortunate in delegating as in exercising their powers. "The present autocratic position of university executives was created for them by the acts of trustees in shifting responsibility for the performance of certain duties from their own shoulders to that of the president and deans" (Stewart Paton). The "quickest and least troublesome way to solve administrative problems is to give as free a hand as possible" to some capable man (J. P. Munroe). The ready vindication of such authority lies in that much-abused term, "efficiency." "When the wisdom of letting a man lord it over an aggregate of employees instead of conferring with a company of scholars is questioned, the answer is the efficiency with which the autocrat can get things done" (J. McK. Cattell). Efficiency undefined and unattached is either the most meaningless[2] or the most dangerous of terms; there are efficient fools and knaves and meddlers and weathervanes and apologists and dissemblers, and most hopelessly the class whose costly efficiency is an eruption of their callous insensibility. Even so directly a utilitarian thing as a signpost is efficient only when you know where you want to go and where not; the term should never be permitted to appear in educational discussions without a chaperone.

The relation of professor to president can not be dismissed at this point. On the one side is the irritating accountability or subserviency or worse. "To hold a Damascus blade over other men's lives, careers, reputations, may still be the fashion in Damascus. The Anglo-Saxon has had the right for uncounted centuries to a full hearing and decision by an open council of his peers" (W. C. Lawton). Given the right type of man, and it may be easy to avoid overbearing in manner or spirit; yet it seems fated to persist in the formal relations of the professor to the administration from which (for one thing) the professor is estranged by a foolish etiquette requiring him, lest he offend by *lèse*

[2] It is worth foot-noting that the Carnegie Foundation which is ostensibly devoted "to the Advancement of Teaching" (yet is governed by a board of college presidents with no representative of the teaching profession) sponsored a report on efficiency in academic affairs, which brought forth the following comment from a journal technically expert to judge the article: "Its whole tenor was to lay emphasis upon the destruction of the academic freedom and initiative that is necessary to the advancement of human intelligence, and to promote that kind of organization which under the guise of uniformity and system effectively suppresses progress" (*Electrical World and Engineer*). And this from a worldly source: "What efficiency experts sometimes forget is that there is a type of ability that can be found and retained better by the offer of a secure and dignified post than by the flourishing of money" (*Springfield Republican*: Editorial). An efficiency primer might well set forth as its first axiom, that it consists in adapting means to ends; its second, that different ends require different means; its third that expertness in means grows out of loyalty to ends. Beyond this, matters are too complex for those who use primers—even for the intelligent and benevolent laity of mature years.

majesté, to accept the president as his representative. The president is thus strongly tempted to run with the hare and hunt with the hounds. With the right of promotion and dismissal comes the right of life and death; to exercise it is to incur the presumption of ὕβρις—to the unspoiled Hellenic conscience the sin beyond pardon. The practical result is too familiar. "The president may assume superhuman responsibility, but he is after all human in his limitations. He may regard common-sense as agreement with him, common loyalty as subservience to him, respect for the opinion of mankind as deference to that small portion of mankind which has money to give" (The Popular Science Monthly: editorial). Transferred from the personal to the corporate relation, the breach in educational policy is coming to be more and more between the professors fundamentally interested in the ends of education and the president and deans dominated in their educational interests by an administrative temper or habit of mind. "The millionaire and the college president are simply middle men who transmit the pressure from the average citizen to the learned classes." "The educated man has been the grain of sand in the college machine. He has an horizon of what 'ought to be,' and he could not help putting in a word and an idea in the wrong place; and so he was thrown out of education in America as he was thrown out of politics in America" (J. J. Chapman). There is at once a conflict of aims and of ideals, thus inviting, according to the type of provocation, a guerilla warfare or a civil war. The system provokes unrest, uncertainty, distrust; it removes harmony, corporate pride, professional independence. So much is clearly to be read in and between the cited lines.

Before resuming speech in the first person, it will be well to consider the rejoinder—the alleged incompetence of the faculties to play the part to which some of them aspire. "It has been said that university faculties are poor legislative bodies; if true, this would not be surprising, so long as their deliberations are confined to discussing questions such as whether they shall wear gowns at commencement, the decision being with the trustees" (J. McK. Cattell). "We appear at present to be between the Scilla of presidential autocracy and the Charybdis of faculty and trustee incompetence. The more incompetent the faculties become, the greater is the need of executive autocracy, and the greater the autocracy of the president, the more incompetent do the faculties become" (J. McK. Cattell). "But was there ever a more vicious circle of argument than that which defends the persistence in a system productive of such unfortunate results by urging that the personnel of the profession has now been brought so low that the restoration of its inherent rights would entail disastrous consequences?" (*Dial:* editorial). From this "lack of opportunity to discuss the larger problems of the university" with authority and responsibility, from this "living in cramped intellectual quarters"

(Stewart Paton) there results the helpless "looking outward for (their) succor" (W. C. Lawton) that makes for resignation not born of strength, and docility not the issue of sacrificing loyalty. No one knows better than the regular attendants at faculty meetings the hesitant, dispirited, nibbling, myopic, lame and wearisome discussions that are a trial to spirit and flesh; but the reasons therefor lie in the "vicious circle" from which they can be released by converting the prisoners into the guardians of a fortress. For any believer in that oldest and perennial source of salvation, the liberation of spirit that makes freemen of slaves, knows what marvels may be accomplished by removing barriers of intellectual restraint, whether shackles, blinders or ghettos. The redemption is through the enthusiasm born of self-assertion, with responsibility as its poise. All bodies long deprived of their constitutional rights tend to become incompetent or nihilistic or restless according to temperament. If disposed to act under a sense of personal injury, they become militant; if organized and with the prospect of control, they become insurgent; if academic, they apparently become dormant. The academic situation suffers from restriction in means and neglect of ends in a confusion of peremptory demands. Reform must be directed to the illumination of ends and means, and primarily to a fitter sense of their kinship. "Administration plays a part in most of our colleges and universities altogether disproportionate to its value. Nor is the objection to this state of things merely negative. There is positive harm of the most serious kind in that submergence of self-assertive personality on the part of the professors which inevitably goes with it" (*New York Evening Post:* editorial). Here lies another vicious circle: we have so much governing to do because we rely so much on governmental machinery and so little on self-government. Yet externalism, however unsuitable and disturbing in itself, is yet more disastrous by reason of its by-products,—the distortion of purpose, the suppression of initiative, the false competitive standards that insinuate themselves in underhand and unforeseen ways, and so little of which is enough to contaminate the whole academic life. It is the common disaster that ensues when those who should lead are subservient to their following, either by force of circumstance or feebleness of principle. In the university above all should the ideals of a sturdy and righteous government be visibly expressed. Its spirit should be progressive. "It appears that the general course of social evolution is not towards competition. In the university it would probably be adverse to the finer traits of scholarship and character, most of all when, as under our present system, the competition would be for the favor of presidents and trustees" (J. McK. Cattell). Faculty incompetence and the restrictedness of academicism—much of which is superficial rather than deep-seated—is not the excuse for but largely the *result of* externalism and of living in the depressed atmosphere which it breeds.

Yet the charge of presumption recurs. Surely the cumulative wisdom that has gone into the guidance of universities would have recognized these untoward influences, would have referred them to their source, and disposed of them, if they were so real and so ominous as this arraignment sets forth.[3] Such a view rests upon a naive faith in the insight and consistency and vertebrate intellectual integrity of able and intelligent men exposed to complex social pressure, which I can not share, and for which history furnishes uncertain warrant. The best intentioned and discriminating men are prone to worship idols or to yield to those who do; the *status quo* of the standpatter easily becomes an obstacle, if not an obsession. Reforms have ever been necessary and will ever be so, so long as new as well as ancient evils yield to an increasing insight or a more sensitive conscience. Favorable or tolerable situations may degenerate as they persist and grow out of helpful relation with the advancing forces that shape our ends. It is not vice alone but many another if lesser untoward influence that first endured or resisted is by familiarity cherished, through vested interests embraced. The personal equation enters; we defend what we have acquired, established, contributed; not "a poor thing, but mine own" but "a good thing because my own" is the attitude assumed toward one's house, or town, or club, or college or automobile. All this weakens the test of fact—the vapid argument that whatever is, is best—and divests radical scepticism of the charge of presumption. Experience requires critical interpretation before it yields its true meaning. It is a common enough situation to find that men progress in their endeavors despite the handicap of the means on which they depend. The successes achieved under the present system are in my judgment partly due to the compensations that lie in every system however unsuitable, yet more largely to the mitigations exercised under considerations foreign to its temper, more plainly to violations of its provisions,—to concessions and forbearance. These the reforms advocated would establish as constitutional rights, as constructive principles fertile in promise, inviting embodiment in practical measures. The gains, the trophies, the tributes are naturally in evidence and properly so; but what of the losses, the ships that have gone down at sea! Moreover bookkeeping in terms of intellectual and spiritual incomes is so difficult; values of ideas are so subject to difference of appraisal by shifting standards, that university

[3] The appeal to experience is curiously partial. If the larger experience of the old world be considered, the burden of proof falls the other way. Externalism does not obtain there in the same manner or temper; presidential autocracy has not been found necessary or desirable; faculty control exists in variable yet always satisfactory measure; and the evils that flourish in American institutions are minimized. It has not been shown that our educational requirements are so wholly peculiar as to demand opposite provisions; it is fairly established that the democratic traditions of the old-world are responsible for some of the mitigations and concessions which have prevented the system of imposed authority from developing its direst possibilities.

authorities are sorely tempted to abandon the attempt and put their investments in real estate—in buildings, plants, and inventories of trade catalogues—to be pointed at with pride so long as one is blessed with an easy conscience. Yet such abandonment means the loss of the soul—an ancient but not negligible hazard. Commencement addresses may be confidently counted upon to pay adequate tribute to the gains and glories of a triumphant education, with an indulgence in fustian in inverse relation to insight. It is plain and crass folly to disregard the losses and possibilities, which however intangible are by no means unreal. The wisest men have always been influenced in their judgment by what might have been; just as the future is shaped by those capable of conceiving what may be.

Reforms return to first principles to get a fair start, and are as often called upon to retrace false steps as to project the course for the future. A university is first and foremost an educational institution ministered to by a company of scholars; it engages many and diverse activities, all contributory to its welfare. Yet no other test of value is relevant than the educational one; no sacrifice in any measure of educational to other interests can be justified; no domination or intrusion of any foreign spirit can be tolerated. These premises lead with the directness of sound logic, with the constant reward that awaits singleness of purpose, to the conclusion that the university interests must be entrusted authoritatively to those expertly conversant with their nature. The professorship must be made a position of honor and authority. The evils that now cause anxiety but corroborate the vital import of academic home-rule; they do not establish its validity; it inheres in the nature of the influence which civilization has shaped to guard the intellectual interests of the race.

It is however important to view the situation in the concrete. By way of illustration I shall survey a few significant consequences of the system, which in turn are of a nature all compact. The directive forces that determine the movement and activities of the academic life do not validly or adequately express the real intentions, demands and ideals thereof; this is the comprehensive and the woeful wrong. The rest is but a bill of particulars, the recurring item in which is that through such suppression, a usurping, distorting predominance is given to a different and an unsuitable range of influences. First is the lack of initiative,—a disqualification the more serious in a career that professes to train for leadership; along with it is the absence of an authoritative referendum. The democratic implication of the terms need not be repudiated, if safeguarded by proper qualifications. The level at which a reference to a composite expression of will is demanded in order to secure the best result—and is not this in reality the aristocratic ideal of government by the most competent?—is reached whenever the qualifications of the referees are adjusted to the issues at stake. Such aris-

tocracy—or to avoid prejudice, let us say isocracy—obtains among the judges of a bench, each presumably qualified to serve, each with like status with the others, yet exercising to the full the qualities of his personality. It is about as appropriate to subject the decisions of a faculty to review by an external board, as it is apt to be constituted, as it would be to have the decisions of the bench reviewed (or influenced, as a suspicious journalism implies is the case) by non-commissioned captains of industry. If the members of the faculty are not qualified to decide educational measures, and to do so broadly, not with a narrow professionalism but with due regard to diversified, at times conflicting, public interests, then there is something seriously wrong about their training or the manner of their election or the influences to which their judgments are exposed. If such incapacity is inherent in the academic character, the appointment of a board of guardians is defensible. Yet initiative is paramount. The more expert judgment is always needed to see *what* is wanted, to frame policies, to make platforms, to raise issues; to decide *whether* this or that is wanted may often be referred with advantage to a wider constituency. To secure a double or a multiple basis of judgment on many-sided issues is a proper function of boards of trustees, corporations and alumni. The usual statement that educational questions are decided by the faculty and financial ones by the board is absolutely specious and is not borne out by practise. There is a group of plainly financial and a group of plainly educational questions; but most questions partake of both aspects. Instead of "hedging," the fact should be frankly met. Old-world precedents—and in favored cases our own usage—abundantly show that and how this may be done. Under the prevailing system the professors neither individually nor collectively settle the important directions in which matters are to move. They await the pleasure or fear the displeasure of the president and deans; and if they move, it is too apt to be with an eye to the man higher up, just as the president is tempted to urge not what his untrammeled judgment approves but what he considers will be approved by the board. The professor does not stand face to face with determinative issues; there is not a considerable body of men thinking of the university as a whole, not a sufficiently corporate sense of their being a whole; the system does not encourage it, distinctly discourages it. The referendum is there but is not unrestricted; it is beset with implications of accountability to another, rather with an independent responsibility. The scope of questions and policies included in the referendum is curtailed. The faculty is at times entrusted with the details of a plan on the general desirability of which it has not been consulted; it receives commissions, conducts a second-table order of deliberation, which makes a sorry feast. All of which is bad for the faculty, as duly set forth; and bad for the university as is also coming to be realized.

The crux of the matter is here reached. Is there or is there not a clash of interests? Do academic needs demand distinctive provisions, distinctive in end and distinctive in means? Are there or are there not economic, political, administrative, individual interests, external sources of pressure, irrelevant or undiscriminating judgments or motives, that conflict with academic purposes? Does the current system of university government impose such restraints and force the organism to an unwholesome existence, weakening the vitality of its expressions, distorting the ends of its being? Here the case, which I have made my case, stands or falls. The statement must be limited to conviction not unsupported by argument. If I am wrong in my primary contention, my plea is vain.

In further illustration of the view that such divergence is real and disastrous, I approach the disagreeable but unavoidable part of my task. I wish it were possible always to speak of the presidency and the professorship and forget the president and the professor; for these objective fictions are really the subjects of discussion. It is also true that in large measure the office shapes the man; yet personality persists despite the difficulty of recognizing in the glorified presidential butterfly the humble professorial worm. The unwise authority and false responsibility of the presidential office invites the incumbent to attempt impossible tasks; invites him to adopt irrelevant standards; to obscure issues by looking many ways and seeing none clearly; to lose the clear-cut distinctions that regulate well-adjusted views and wholesome leadership. A despondent colleague insists that the only type of man safely to be entrusted with the prerogatives of the presidency is one whose principles would require him to decline the office. The dismal problem of salary shows the situation at its worst. (Let me assure the reader that I shall not expose the futility of the professor's financial manipulations to the kindly scorn of an affluent public; it is so magnanimously conceded that he is grievously underpaid, that there is still hope that the grief may assume a pragmatic form.) It is the chaotic adjustment, the introduction of the methods of the auction-room and the stock-market that have totally obscured the fact that there are principles at stake. What is wrong to the core is the attempt to translate academic service into dollars by an esoteric procedure which only presidents understand and will not reveal. It is possible to recognize the sublimity of Don Quixote's courage in his grotesque ventures, or of Chanticleer's confidence in his relation to the solar system, though disturbed by a humiliating mischance; but the administrative alchemy seems only ridiculous; while the waving of the magic wand of "merit" is irritating because so specious and so futile.

Principles are as clear as practise is muddy. More significant for wise adjustment is what a man is paid for, than what he is paid. Salary represents an adjustment of resources to needs, to the composite

factors of the situation viewed academically, not commercially. The folly of trying to serve two masters is as patent here as elsewhere. Those who are worried lest men of unequal merit receive like salaries reveal the commercial bent of their minds; the academic concern is rather that men of like merit may receive unequal salaries. But salaries can not be regulated on the principle that it is pleasant to receive them. Rewards of merit and Christmas stockings doubtless have their place, but in the light of the lamp of learning, they seem a bit tawdry; nor does it seem helpful to punish service that does not fulfill promise by imposing complications in settling butchers' and grocers' bills. If professors are going to scramble for incomes, they lose all claim to the partial release from the economic pressure which their prerogative claims. The whole wretched business is mismanaged and causes more needless misery than it is proper to disclose. The security of the professorship is involved; the integrity of great academic traditions is involved; the soundness and poise of the intellectual life is involved. Indeed so much is involved that the enumeration might suggest to the uncharitable that the academic nervous system finds its solar plexus in the purse. The commanding consideration is that such is not the case; and the public should be prevented from so regarding it. Salvation lies in holding fast to the plain truth that this, like all other questions, must be considered and settled as an academic one. Any system will be good—though some will be better than others—that is, framed on that principle and on no other; that holds to it steadily, come what may; that solves salary questions by preventing nine tenths of them from arising; that does not invidiously discriminate between men on a money basis; that gives a man an independent seat in an academic counsel and relegates the pay day to its proper place in the calendar. "A single university which acts in this way" [*i. e.*, makes tenure and preferment dependent on the president's ukase] "will in the end obtain a faculty consisting of a few adventurers, a few sycophants and a crowd of mediocrities"; if all universities do so, able men will not embark "on such ill-starred ships" (J. McK. Cattell). But the world is slow to banish the money-changers from the temple of learning; and, sad to confess, the custodians of the shrine have invited the disturbance of their offices by considerations of the market.[4] They

[4] It is clear that I am not reviewing the salary question, but am touching only on one phase of the principles affecting its solution. The question was discussed five years ago by an association, composed of the presidents and deans of a score of the foremost universities, which is sufficiently naive or presuming to call itself "The Association of American Universities." Only one protagonist stood out against his associates for an uncompromisingly academic adjustment. Let me record my optimism in my belief that he would not stand alone to-day. I am not in the least unaware of the many difficulties that beset the practical adjustment of salaries to condition; nor do I forget that at some stage a modus vivendi between academic and economic demands must be arranged. This does not in the least excuse the reply of a president to a plea for the

have indeed been hard pressed; whether this condones the offence let each judge. It is the common case of advancing a good end by bad means, thus sacrificing a larger benefit for an immediate gain; yet in so doing—and that is the sacrilege of it—the integrity of the end is compromised, the worship of false gods sanctioned.

The largest field of conflict between the standards and consequent views and favored policies of the academic interests and those associated with administrative measures is that of educational provisions. It is true that the divergence is more commonly partial than total; yet cumulatively it is momentous,—a chronic if not acute ailment. It is not easy to illustrate it without becoming tedious. I shall choose a phase in which the public is interested. How does it affect the student, the manner of life which he is invited to lead; the influences to which he is exposed; the curriculum to which in theory he is subjected and in practise too commonly orders by devising a mingled *à la carte* and *table d'hôte* menu not contemplated in any well-designed European or American plan of education. His very presence in college or in a particular college may be a result in which the administrative emphasis has been a cause; for there are so many of him (or her) that are in college without due warrant of present fitness and future benefit. The bidding for numbers is part of the system that operates to the disadvantage of standards; for the size (not the quality) of the share of the annual freshman crop, when reported, affects the rating in the educational Bradstreet. Prosperity is statistically measured; hence the desire for more buildings and costly ones; for more instructors, many of them occupied in work that the college should require and not provide; and more and more students who must be attracted towards the local Athenopolis and away from the rival one. Accordingly the hills are all reduced to easy grades and new democratic (not royal) roads to learning are laid out for those who do not like the old ones. Requirements are set not to what collegians should learn but to what they will; as at the circus the strip of bunting is held ostentatiously high until the horse with its fair burden is about to jump, when it is inconspicuously accommodated to the possible performance. Still more fatal is the continuance of a like spirit within the college; competition is encouraged for large classes and big departments; each professor bids for students, and students have the air of patronage when they choose the

academic adjustment: "I have never been able to manage a university" (note the language) on that plan. That statement is a confession of unfitness. It would be invidious to point out how this or that institution has admirably solved one or another phase of the problem. There is sufficient proof that a reasonable solution can be reached even under present conditions. I also offer the two-edged philosophic consolation that since salary can not possibly reflect merit, it does a man no good and no harm to receive more or less of it than do his colleagues. Perhaps this truth should be kept for home consumption; to offer it to the public may lead to complications.

wares on his counter. It is difficult to have one eye on popularity and the other on scholarship and retain a concentrated attention. A confessional questionnaire upon the motives operative in electing studies would reveal family secrets, difficult to reconcile with the lofty provisions and disinterested opportunities of the catalogue.

Involved in this rivalry, friendly in appearance, deadly in effect, is the intrusion of over-practical, quasi-professional interests, to the disparagement of discipline and cultural ideals. It is as though the course of the ship of education were determined by consulting the passengers. Advertising looms large and boosts the bigness that brings revenues and responds to administrative ambitions. The general consequence, I contend, is that the policies pursued, the measures adopted, that determine what students do at college and how they do it, and what they fail to do, neither truly nor adequately reflect the intent, the wisdom, the influence of those to whom they rightly look for guidance. Let me concede at once that some of the above trends are within limits legitimate and helpful, and again that in considerable measure they are not wholly or predominantly due to the administrative influence. None the less the administrative emphasis must be charged with a large responsibility for the excess to which the natural derogations of youth have been permitted to expand.[5] The administrators have held the balance of power; they have ruled by overruling; or by yielding where resistance was demanded. If theirs is the pride, theirs is also the shame.

There can be no doubt that college life is generally and severely criticized. The perspective of student activities seems to the casual as to the close observer sadly out of joint; and this extends to more than the fact that for news of the colleges one must turn to the prismatic sporting pages of enterprising dailies. The query whether the collegiate side-shows have not eclipsed the business carried on in the main tent, if carried further, may lead to similar revelations as to the altered spirit of the performance in the academic arena. The arraignment is long and severe: students have no intellectual interests, no application, no knowledge of essentials, no ability to apply what they assimilate; they are flabby, they dawdle, they fritter and frivol, they contemn the grind, they miseducate the studious, they seek proficiency in stunts, they drift to the soft and circumvent the hard; undertrained and overtaught, they are coddled and spoon-fed and served where they should be serving; and they get their degree for a quality of work which in an office would cost them their jobs. You may read it seriously and impressively set down in Mr. Flexner's "The American College"; you may read it no less forcibly if more indulgently recorded in Mr. Gay-

[5] Since writing these words Mr. Owen Johnston has set forth in no uncertain temper the ''Shame of the Colleges'' in terms of undergraduate dissipation, not as ominous in its physical extravagance as in its intellectual waste. It is the undergraduate distortion of perspective that is the source of despair, and for which the academic authorities must accept a considerable responsibility.

ley's "Idols"; you may find it undisguised in Mr. Dooley's satire, and dramatically staged in "Stover at Yale." Parents are uneasy about the value of it all when their sons are in college (parenthetically with some one's else daughters); their worldly employers question it more pragmatically when college days are over. Alumni are divided between an indulgent retrospective loyalty and the enlightenment of maturer wisdom. All this smoke points to a constantly smouldering dissatisfaction, bursting occasionally into a flame of protest. Doubtless the causes of the situation so variously complained of, like the causes of the high rate of living, are both deep and wide. Yet it seems clear that things would not have drifted so rapidly nor so far, if the machinery of the university had been made more directly responsive to the educational sentiment. It is not so much a question of conservative or liberal, of standpatter or progressive. It is a question of a proper perspective and of the power to enforce it—of foreground and background, of what shall be put first and what second and what last.

Further illustration would encroach upon complex scholastic matters. One group of issues centers about the manner in which the university ideal is to be maintained while meeting and yet resisting the public pressure, or directing it to fruitful channels; for the university should be at once responsive and responsible. The several legitimate influences bearing upon educational provisions, whether publicly or privately supported, should have avenues of expression and of enforcement. Their adjustment is a delicate matter in which the representation of opinion and the disposition of authority will be both just and wise if the several factors are given due order of precedence. It is a question requiring argument, but must here be dismissed with the conviction that the academic representation is far too slight and unauthoritative, that the evils developed and others in the making are largely due to the overshadowing of academic by administrative interests. All this is but natural. Let any one of a group of interacting factors gain a headway, and the acquired momentum accumulates about it further aggrandizement unless opposed by rival forces. This type of greatness comes both by birthright of office, is achieved by set purpose, and is thrust upon the conspicuous recipient. Add to this the natural heedlessness exemplified in a prosperous and expanding environment—so pointedly shown in the exploitation of natural resources, now checked by the movement for conservation—and it becomes clear how sound policy has been sacrificed to temporary expediency, to the desire to get things done, to the neglect of the criterion of quality that in the end makes or mars. Think of the superfluous ease with which colleges and universities have been sprinkled over the land, and the misguided zeal of local ambition, and the passion for quick returns; and how inevitably must academic interests suffer under such pressure, how inevitable that administrators should seize and hold the reign of government to the

retirement of the calmer, sober claims of sound education! So far as youth and the frontier is the excuse, it no longer obtains. We are of age; nor is it so much a matter of age as of tradition. It is the survival of an unwholesome tradition into a state of affairs in which it becomes a hindrance and not a help, that constitutes the administrative peril.

A retrospect suggests the prospect and foreshadows it. I find some difficulty in attaining the degree of despondency which the outlook demands. There are many signs of a reaction against the system; while, as I have repeatedly noted, the spirit of the academic relations has steadily improved, and will, I am confident, lead in the directions of the reforms so urgently desired. The ability, earnestness, and eagerness to cooperate, on the part of governing boards, is itself a sufficient assurance. They are becoming sensitive to their externalism, and recognize the unwisdom of snapshot judgments of momentous issues, concerning the pros and cons of which they are increasingly reluctant to accept the president's view as representative. The retrospective contrast is indeed amazing. It falls just beyond my experience to have members of the faculty addressed by a member of the board as "You men whom we hire." It is within my experience to have professors summoned inquisitorially before a committee of the board to give an account of themselves, the interview conducted by the chairman with his feet on the table, and displaying a salivary agility that needs no further description. Such reminiscences carry no sting; they are merely amusing because now so impossible. They are instructive as showing how quickly the products of a world-culture follow upon the receding frontier. It lies in the power of governing boards to restore the academic prerogative. A movement in this direction would be in accord with the tendency in public affairs to correct national weaknesses and to revise cruder codes of procedure.

Returning some years ago from a prolonged sojourn abroad, I was on the watch for the first convincing incident that would reflect the American trait. Emerging from the attentions of the customs officials, who lost no time in showing me my place in their scheme of existence, I was accosted at the gates of liberty by a foreign urchin with the breezy offer: "Carry your bags, Boss?"—in his own land it would have been "Signor." I recognized the title as the proper address for the returning American citizen. But now the boss, political, industrial, or educational, is no longer in such high repute as to make the term an unquestioned compliment. Methods are coming to be scrutinized, policies challenged, rights and wrongs as well as successes considered, and ethical and social as well as economical balance-sheets demanded. All this makes for a refinement in the adjustment of means to ends which is sympathetic with my plea. It is natural that the men of affairs chosen for posts of honor, so many of them of the high-principled classes

responsive to the higher standards, should become sensitive to the autocracy in educational administration and look upon it with distrust. They understand, if they do not embrace, the cause of academic insurgency. They may be few in number, even exceptional; they are growing in influence. But the professor must not look passively for relief from without; he must find it within his guild. The clouds of promise though small are visible above the horizon. Protests are growing and are no longer received as dangerous or pardonable idiosyncrasies. The class of men from which presidents are recruited shows a considerable group alert to the evils of the system which they are called upon to administer. Programs of reform have been proposed: advisory bodies to offset presidential autocracy and make the position representative; the election of the president by the faculty together with the determination by the faculty of the powers which he is to exercise; the abolition of the office altogether. Speaking some years ago in a conciliatory mood, I favored the gradual elimination by reformatory measures of the most serious administrative evils, and trusted to the spirit thus awakened to carry the movement to a fitting consummation. I confess that the logic of the abolitionist position is growing upon me. It seems in so many ways disturbing to have a commanding figure in the academic horizon; the foolish and increasing pomp and circumstance of each presidential inaugural deepens the impression. Yet I still believe that the presidential office, shorn of its unwise and unsafe authority, of its aloofness in salary and lime-light conspicuousness, of the prerogatives which it has assumed because unclaimed (or, in the vernacular, because not securely nailed down), could be adjusted to accomplish all the essential desiderata. I believe this mainly because I believe that the position thus reconstructed would attract a different type of man—one who would desire to be no more and no less than an academic leader serving by the warrant of election and of constitutional support by the body which he serves. Clashes of policy must be avoided by the fusion of interests, not by the imposition of an external authority.

The rectification of the greatest loss constitutes the restoration of the greatest gain. The independence of the academic career as embodied in the status of the professor remains the *noeud vital* of the educational system. Untoward conditions affect the intellectual economy unfavorably from its lowest to its highest ramifications. The blight of the blossoms is often caused by the impoverished soil at the roots. It is at the upper levels of fruition where growth is most sensitive to climatic influences that the hazard is greatest. In acknowledging the honorary degree which Harvard University conferred upon William James to make him yet more distinctively her own, he offered in return the concentrated expression of his academic experience. "The university most worthy of rational admiration is that one in which your lonely thinker can feel himself least lonely, most positively furthered, and

most richly fed." In reminding the alumni of Harvard that "our undisciplinables are our proudest product" he gave expression to a memorable reflection. The administrative temper breeds an atmosphere peculiarly noxious to the finer, freer issues of learning. The inner quality so precious to the function of leadership in intellectual callings, dependent as they are on the delicate nurture of the creative gift, is precisely that which recedes at the first harsh touch of imposed restraint. There is a temperamental disposition involved, fraught with difficulty of adjustment under the most favorable circumstances, beset with hazard throughout its uncertain maturing at all levels. Unless the academic life is made helpful to its purpose, the course of which it must so largely be free to set for itself, the ships that bear our most valued cargoes will be storm-tossed and needlessly discouraged in their efforts to reach their sighted harbors; and some of them will mutely and ingloriously go down at sea. It is because the prevalent administrative system is so deadly to "our proudest product," that it appears to me, through the vista of a quarter century, as the supreme peril of the educational seas.[6]

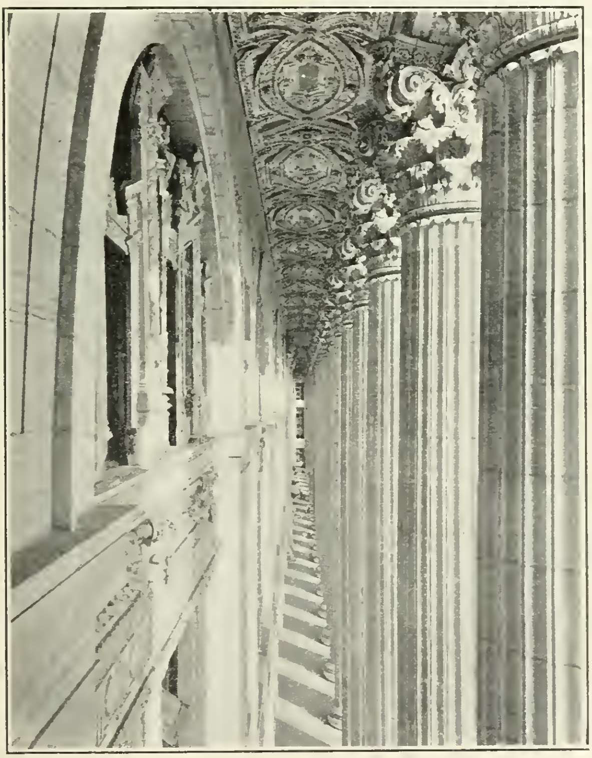
[6] Since this article was written, Professor Cattell has made known the results of his inquiry in regard to the opinions of professors upon the desirability and acceptability of the present system of academic control. (See *Science*, May 24 and 31, 1912). Speaking generally the inquiry, which was conducted upon a wide basis and presumably a frank one, reveals the astonishing conclusion that 85 per cent. of the replies are unfavorable to the system in vogue—the system here criticized. It is even more significant that a large majority advocate a very decided and radical reconstruction to bring about an urgently needed reform. The variety of points of view from which the dominant system is attacked is also suggestive. Knowing as I did from the many letters of endorsement of my own utterances, that there was a wide-spread sympathy with this position, I was yet entirely unprepared to find so general an expression of dissatisfaction. It would appear that the professors constitute a fairly unanimous army of insurgents, with a peculiar reticence in announcing their cause, and a reluctance to enlist in any active operations. None the less the statistical result is a cause for congratulation; and the academic world owes a debt to Professor Cattell the nature of which the future will more clearly reveal. Of the several constructive suggestions those advanced by Professor Cattell must now be accorded the preferred position, since it is with reference to them that a representative referendum of the academic profession has been taken. When it is realized that a considerable majority favors an extensive reconstruction of the system as established, and that the professors as a body find themselves dispirited and not inspired by the provisions supposed to ensure their efficiency, it is hardly probable that boards of management will fail to respond to this convincing and notable evidence that there is something out of joint in the academic situation. In my opinion Professor Cattell has indicated a workable, flexible program. As a platform its stability will depend not so directly upon this or that plank which is inserted or omitted or trimmed to local requirements, as upon its finding a solid support in the sentiments and judgments of those whose business and privilege it will be to direct its construction, as at once a visible and a spiritual reality.

New York State Education Building.

THE PROGRESS OF SCIENCE

THE DEDICATION OF THE NEW YORK STATE EDUCATION BUILDING

THE New York State Education Building was dedicated on October 14, with ceremonies commensurate with the magnificence of the building and the importance of the educational work of the state which it represents. The principal address was made by the commissioner of education, Dr. Andrew S. Draper, to whose efforts the building is in large measure due, and there was a program extending over three days, with a number of important addresses. These included one by Dr. William H. Maxwell, superintendent of the schools of New York, on behalf of elementary education, one by Dr. J. C. Schwab, librarian of Yale University, on behalf of the state library, one by Dr. Henry Fairfield Osborn, president of the American Museum of Natural History, on behalf of the state museum, and one by Dr. Van Hise, president of the University of Wisconsin, representing the work in educational extension for which that university has accomplished so much. Ambassador Whitelaw Reid, chancellor of the University of the

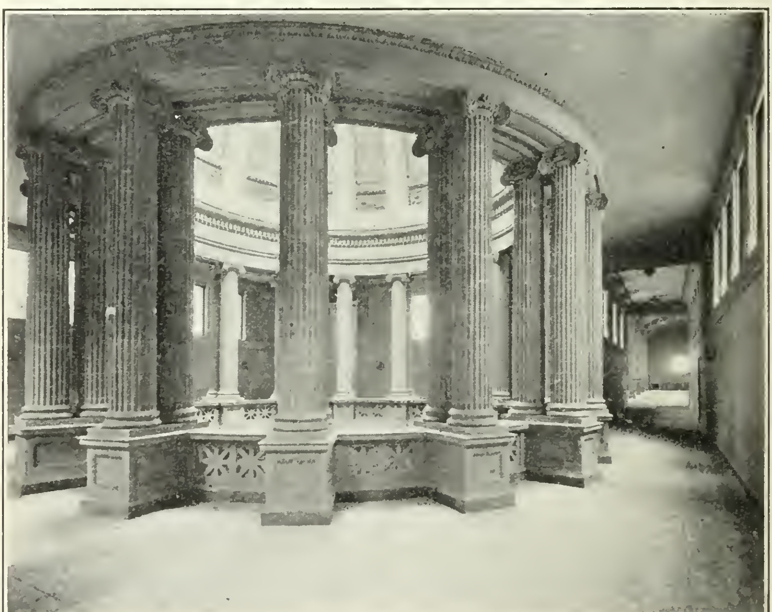


LOGGIA, BEHIND THE SOUTH COLONNADE.

State of New York, came from England to preside and to deliver one of the addresses.

The University of the State of New York was created to supervise colleges and academies by the legislature in 1784, at its first session after the peace, and the Department of Education was created in 1812 to supervise the state system of common schools. In both respects New York led the other states and it may be all countries. The two departments were united by law in 1904, and they now have an impressive building to represent their work. The need of such a building was urged by the commissioner of education in 1905 and recommended by the regents, and in 1906 the legislature appropriated some four million dollars for the building and its site. As a result of an elaborate architectural competition, in which sixty-three designs were submitted, the plans of Messrs. Palmer and Hornbostel were accepted, and the building shown in the accompanying illustrations has now been erected.

The façade consists of a great colonnade of many Corinthian columns, behind which is a series of semi-circular openings allowing a large window area. The end façades are modifications of the front, the columnar treatment being carried across the ends. The front and end façades of the building are of white marble and terra cotta on a dark granite base. The basement contains rooms for service of all kinds, the lower part of the auditorium and the lower floors of the great book stack of the library. The first floor contains rooms for the regents and the commissioner of education with other offices, including those for the library division and state examination board. The second floor contains reading rooms opening on the stack room, with a capacity of two million volumes. The third floor contains offices and work rooms for the examination division and extension division and the library school, and the upper part of the library. The fourth floor is devoted entirely to the state museum and contains its collections in geology, mineralogy, paleon-



DOME OF THE FOYER, LOOKING INTO THE HALL OF ZOOLOGY.

PART OF THE HALL OF GEOLOGY.

tology, zoology, botany and archeology. The principal room is 570 feet in length and 50 feet in width, and is lighted from above. The offices of the director of the museum, Dr. J. W. Clarke, and his assistants are placed on a mezzanine, adjacent to the exhibition rooms.

The building should have been completed on January 1, 1911, in which case the collections of the education department and the state library would have escaped the serious injury caused by the fire which destroyed the west half of the capitol on March 29, 1911. The legislature has, however, appropriated a million and a quarter dollars to reestablish and enlarge the state library, which in size ranks fourth among the libraries of the country. The state museum has admirable collections due to the long line of distinguished men who have been connected with it. New York state spends annually about seventy-five million dollars for education, and it is becoming that it should now have a building which suitably represents the magnitude and importance of its educational work.

AGRICULTURAL PRODUCTS OF THE UNITED STATES

THE value of the farm products of the United States has been increasing year by year. If their value in 1899 is represented by 100, the increase for each of the following six years was about six points; for 1906 the increase was 10, for 1907 it was 15 and for 1909 it was 16. There was a lowering in 1910 of the rate of increase to less than two, the point then reached being 184.3, or nearly double the value twelve years before. In 1911, the decline shown in 1910 became emphasized, and the index number fell to 178.4. The total value of farm products was $277,000,000 under the total for 1910.

In the report of the secretary of agriculture, from which these figures are taken, the decline is attributed to conditions of climate, there having been a combination of hot weather and a deficiency of rainfall in the early part

of the year. The loss, however, is due to animal products and not to crops, the former having decreased over $300,000,000 in value, and the latter having gained nearly $50,000,000. The total value of farm products reached the great total of eight billion four hundred and seventeen million dollars.

Corn is the leading crop of the country, being double in value that of cotton and being three quarters the total production of the world. The amount produced last year was a little under the average for the preceding five years, but the value was greater than ever before. The United States produces about three fifths of the cotton of the world and the exports amounted last year to $585,000,000, or more than a quarter of all exports. The crop of cotton last year was the largest ever grown, but the price declined. Hay, which stands next to cotton and is close to it in value, gave last year the smallest crop produced since 1888. Wheat, worth about $600,000,000, was in quantity about five per cent. below the five-year average. Oats, fifth in order of value, decreased in quantity, but rose in price. Potatoes yielded about 90 per cent. of the average production, but the crop sold for more than ever before. Next in order of value were barley, tobacco, flaxseed, rye, sugar beets, hops, rice and buckwheat. The refined beet sugar produced in the country greatly increased, amounting to the value of $90,000,000, while cane sugar is valued at $45,000,000.

According to preliminary official reports the crops in 1912 will surpass all others in the history of this country. Eight billion dollars a year for farm products is an enormous sum. We should not, however, forget that at least one fourth of this vast amount represents the natural fertility of the soil which we are consuming. So much should surely be saved for permanent improvements, buildings, tools, stock, roads, etc., and the most profitable and permanent of all investments, the education, health and welfare of the people.

SCIENTIFIC ITEMS

We record with regret the deaths of Dr. Lewis Boss, director of the Dudley Observatory, Albany; of Professor Morris Loeb, the distinguished chemist of New York City; of Dr. Leonard W. Williams, instructor in comparative anatomy at the Harvard Medical School, and of Professor Williston S. Hough, dean of the Teachers College and professor of philosophy at the George Washington University.

Dr. Alexis Carrel, of the Rockefeller Institute for Medical Research, has, according to cablegrams from Stockholm, been awarded the Nobel prize in medicine. Dr. Carrel, who was born in France in 1873, has carried forward important research work in experimental pathology, physiology and surgery.—Mr. A. Wendell Jackson, who has arranged a loan of $50,000,000 to China, in opposition to the offers of the financiers of the six great powers, is a mining engineer who was formerly professor of mineralogy and economic geology at the University of California. He is a fellow of the American Association for the Advancement of Science and a fellow of the Geological Society of America.

Sir W. H. White has been elected president of the British Association for the Advancement of Science for the meeting to be held next year in Birmingham.—At the eighty-fourth meeting of the German Association of Scientific Men and Physicians held recently at Münster, it was decided that next year the meeting will be held at Vienna, under the presidency of Professor H. H. Meyer.—The fourteenth meeting of the Australasian Association for the Advancement of Science will be held in Melbourne in January, 1913.—The International Congress of Mathematicians recently meeting at Cambridge adjourned to meet in Stockholm in 1916.

THE POPULAR SCIENCE MONTHLY.

DECEMBER, 1912

THE EVOLUTION OF THE DOLLAR MARK

By Professor FLORIAN CAJORI
COLORADO COLLEGE

THERE are few mathematical symbols the origin of which has given rise to more unrestrained speculation and less real scientific study than has our dollar mark, \$. About a dozen different theories have been advanced by men of imaginative minds, but not one of these would-be historians permitted himself to be hampered by the underlying facts. These speculators have dwelt with special fondness upon monogrammatic forms, some of which, it must be admitted, maintain considerable antecedent probability. Breathes there an American with soul so dead that he has not been thrilled with patriotic fervor over the "U. S. theory" which ascribes the origin of the \$ mark to the superposition of the letters U and S? This view of its origin is the more pleasing because it makes the symbol a strictly American product, without foreign parentage, apparently as much the result of a conscious effort or an act of invention as is the sewing machine or the cotton gin. If such were the case, surely some traces of the time and place of invention should be traceable; there ought to be the usual rival claimants. As a matter of fact no one has ever advanced real evidence in the form of old manuscripts, or connected the symbol with a particular place or individual. Nor have our own somewhat extensive researches yielded evidence in support of the "U S theory." The theory that the \$ is an entwined U and S, where U S may mean "United States" or one "Uncle Sam," was quoted in 1876 from an old newspaper clipping in the *Notes and Queries* (London):[1] it is given in cyclopedic references. In the absence of even a trace of evidence from old manuscripts, this explanation must give way to others which, as we shall find, rest upon a strong basis of fact. Possibly these

[1] *Notes and Queries*, 5th S., Vol. 6, London, 1876, p. 386; Vol. 7, p. 98.

statements suffice for some minds. However, knowing that traditional theories are dear to the heart of man, an additional *coup de grace* will not be superfluous. The earliest high official of the United States government to use the dollar mark was Robert Morris, the great financier of the Revolution. Letters in his own handwriting, as well as those penned by his secretary, which we have seen,[2] give the dollar mark with only one downward stroke, thus $. To assume that the symbol is made up of the letters U and S is to assert that Robert Morris and his secretary did not know what the real dollar symbol was; the letter U would demand two downward strokes, connected below. As a matter of fact the "U S theory" has seldom been entertained seriously. Perhaps in derision of this fanciful view, another writer declares "surely the stars and stripes is the obvious explanation."[3]

Minds influenced less by patriotic motives than by ecclesiastical and antiquarian predilections have contributed other explanations of our puzzle. Thus the monogrammatic form of I H S (often erroneously interpreted as *Jesus, Hominum Salvator*) has been suggested.[4] The combination of H S or of I I S, which were abbreviations used by the Romans for a coin called *sestertius*, have been advocated.[5] We should expect the supporters of these hypotheses to endeavor to establish an unbroken line of descent from symbols used at the time of Nero to the symbols used in the time of Washington. But sober genealogical inquiries of this sort were never made or, if made, they brought disaster to the hypotheses.

An interesting hypothesis is advanced by the noted historian, T. F. Medina, of Santiago de Chile. He suggests that perhaps the dollar mark was derived from the stamp of the mint of Potosi in Bolivia. This stamp was the monogrammatic *p* and *s*. Against the validity of this explanation goes the fact that forms of *p* and *s* were used as abbreviations of the "peso" before the time of the establishment of the mint at Potosi.

All the flights of fancy were eclipsed by those who carried the $ back to the "Pillars of Hercules." These pillars were strikingly impressed upon the "pillar dollar," the Spanish silver coin widely used in the Spanish-American colonies of the seventeenth and eighteenth centuries.[6] The "Pillars of Hercules" was the ancient name of the opposite promontories at the Straits of Gibraltar. The Mexican

[2] Letter of 1792 in Harper Memorial Library, University of Chicago; Robt. Morris's Private Letter Book in MSS. Div. of Library of Congress.

[3] *Notes and Queries*, 5th S., Vol. 6, p. 434.

[4] "Standard Dictionary," Art. "Dollar."

[5] M. Townsend, "United States, an Index, etc.," Boston, 1890, p. 420.

[6] *Notes and Queries* (London), 5th S., Vol. 7, 1877, February 24; "New American Cyclopædia," Vol. VI., 1859, Art. "Dollar."

"globe dollar" of Charles III. exhibited between the pillars two globes representing the old and new worlds as subject to Spain. A Spanish banner or a scroll around the pillars of Hercules was claimed to be the origin of the dollar mark.[7] The theory supposes that the mark stamped on the coins was copied into commercial documents. No embarrassments were experienced from the fact that no manuscripts

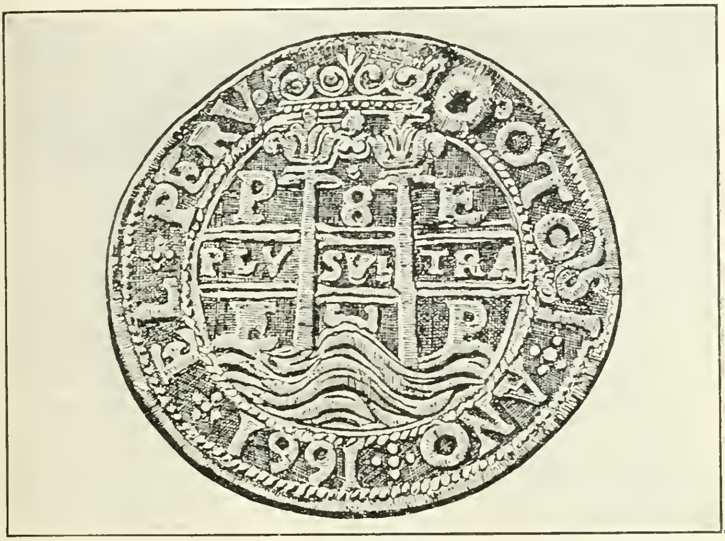


FIG. 1. "PILLAR DOLLAR" OF 1661, showing the "Pillars of Hercules." (From "Century Dictionary," under "Pillar.")

are known which show in writing the imitation of the pillars and scroll. On the contrary, the imaginative historian mounted his Pegasus and pranced into antiquity for revelations still more startling. "The device of the two pillars was stamped upon the coins" of the people who "built Tyre and Carthage"; the Hebrews had "traditions of the pillars of Jachin and Boaz in Solomon's Temple," "still further back in the remote ages we find the earliest known origin of the symbol in connection with the Deity. It was a type of reverence with the first people of the human race who worshipped the sun and the plains of central Asia." The author of this romance facetiously remarks, "from thence the descent of the symbol to our own time is obvious."[8] Strange to say, the ingenious author forgot to state that this connection of the dollar mark with ancient deities accounts for the modern phrase, "the almighty dollar."

Most sober-minded thinkers have been inclined to connect the dollar

[7] M. Townsend, *op. cit.*, p. 420.

[8] "American Historical Record," Vol. III., Philadelphia, pp. 407–8; *Baltimore American*, June 3, 1874.

symbol with the figure 8. We have seen four varieties of this theory. The Spanish dollars were, as a rule, equivalent to eight smaller monetary units, universally know in Spain as "reales" or "reals." The "pillar dollar" shows an 8 between the two pillars. The Spanish dollar was often called a "piece of eight." What guess could be more natural than that the 8 between two pillars suggested the abbreviation |8|, which changed into $? So attractive is this explanation that those who advanced it did not consider it worth while to proceed to the prosaic task of finding out whether such symbols were actually employed in financial accounts by merchants of English and Latin America. Other varieties of theorizing claimed a union of P and 8 ("piece of eight")[9] or of R and 8 ("eight reales")[10] or of |8| (the vertical lines being marks of separation)[11] or of 8/.[12] The "P8 theory" has been given in Webster's "Unabridged Dictionary," not in its first edition, but in the editions since the fourth (1859) or fifth (1864). It is claimed that this widely accepted theory rests on manuscript evidence.[13] One writer who examined old tobacco account books in Virginia reproduces lithographically the fancifully shaped letter *p* used to represent the "piece of eight" in the early years. This part of his article is valuable. But where it comes to the substantiation of the theory that $ is a combination of P and 8, and that the $ had a purely local evolution in the tobacco districts of Virginia, his facts do not bear out his theory. He quotes only one instance of manuscript evidence and the reasoning in connection with that involves evident confusion of thought.[13] To us the "P 8 theory" seemed at one time the most promising working hypothesis, but we were obliged to abandon it, because all evidence pointed in a different direction. We sent inquiries to recent advocates of this theory and to many writers of the present day on early American and Spanish-American history, but failed to get the slightest manuscript evidence in its favor. None of the custodians of manuscript records were able to point out facts in support of this view. We ourselves found some evidence from which a superficial observer might draw wrong inferences. A few manuscripts, particularly one of the year 1696 from Mexico (Oaxaca), now kept in the Ayer Collection of the Newberry Library in Chicago, give abbreviations for the Spanish word "pesos" (the Spanish name for Spanish dollars) which consist of the letter *p* with a mark over it that looks much like a horizontal figure 8. This is shown in Fig. 2. Is it an 8? Paleographic study goes against this conclusion: the mark signifies "os," the last two letters in "pesos." This is evident from

[9] M. Townsend, *op. cit.*, p. 420; *Scribner's Magazine*, Vol. 42, 1907, p. 515.

[10] M. Townsend, *op. cit.*, p. 420.

[11] *Notes and Queries* (London), 5th S., Vol. VII., p. 317.

[12] *Scribner's Magazine*, Vol. 42, 1907, p. 515.

[13] *American Historical Record*, Vol. III., p. 271.

several considerations. The fact that in the same manuscript exactly the same symbol occurs in "vez^{os}," the contraction for "vezinos," or "neighbors," may suffice; an 8 is meaningless here.

We have now described the various hypotheses.[13a]. The reader may have been amused at the widely different conclusions reached. One author gives to the \$ "a pedigree as long as chronology itself." Others allow it only about 125 years. One traces it back to the worshippers of the sun in central Asia, another attributes it to a bookkeeper in a Virginia tobacco district. Nearly every one of the dozen theories seemed so simple to its advocate as to be self-evident. A mode of argumentation is revealed much like that of the prospective western farmer planning to solve the problem of irrigation by planting rows of potatoes between rows of onions, " to make the potato-eyes water." He was thoroughly infatuated with the brilliancy of his idea and of course never subjected it to a sober test.

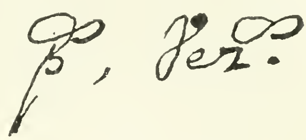


FIG. 2.

In our own researches we have been driven from one working hypothesis to another, until finally we found one which tallied with the facts. Noticing that as a rule the common abbreviations for monetary units used in recent centuries consisted in the initial letter, or that letter and a second one in the word, as M for the German "mark," *fr.* for the French "franc," £ for the English "pound" (libra), we started with the provisional theory that \$ came from the letters in the word "dollar." To test the theory we began the examination of colonial manuscripts and made galloping progress in showing that "dollar" was in colonial days actually abbreviated to "Dolls.," "Doll.," "Do.^{s}," "D^s," "D." But in endeavoring to show the evolution of D into \$ we encountered insuperable difficulties. Thousands of manuscripts were looked over and they absolutely failed to supply the necessary connecting links. We had to throw our theory overboard as a useless burden.

The history of the dollar mark is difficult to trace. The vast majority of old documents give monetary names written out in full. This is the case also in printed books. Of nine Spanish commercial arithmetics of the seventeenth and eighteenth centuries, five gave no abbreviations whatever for the "peso" (also called "piastre," "peso de 8 reales," "piece of eight," "Spanish dollar"). In fact some did not mention the "peso" at all. The reason for the omission of "peso" is that the part of Spain called Castile had monetary units called "reales," "ducados," "maravedises," etc.; the word "peso" was used mainly in Spanish America and those towns of Spain that were in

[13a] Interesting lines of research on the origin of \$ were suggested by Professor D. E. Smith in his "Rara Arithmetica," 1908, pp. 470, 471, 491, but we found them barren of results.

closest commercial touch with the Spanish colonies. After the conquest of Mexico and Peru, early in the sixteenth century, Spanish-American mints, established in the various points in the Spanish possessions, poured forth the Spanish dollar in such profusion that it became a universal coin, reaching before the close of the century even the Philippines and China. In the seventeenth century the Spanish "piece of eight" was known in Virginia and much was done to promote the influx of Spanish money into that colony. The United States dollar, adopted in 1785, was avowedly modelled on the average weight of the Spanish dollar coins in circulation. Thomas Jefferson speaks of the dollar as "a known coin, and the most familiar of all to the minds of the people."[14] No United States dollars were actually coined before the year 1794.[15] We proceed to unfold our data and to show the evolution of the dollar mark by stages so easy and natural, that the conclusion is irresistible. There are no important "missing links." To enable the critical reader to verify our data, we give the sources of our evidence. No man's *ipse dixit* is a law in the world of scientific research.

We begin with information extracted from early Spanish printed books, consisting of abbreviations used for "peso" or "pesos."

Ivan Vasquez de Serna,[16]	1620,	*Pes., pes de 8 real.*
Francisco Cassany,[17]	1763,	*p,* also *ps.*
Benito Bails,[18]	1790,	*pe,* seldom *p.*
Manuel Antonio Valdes,[19]	1808,	*ps.*

Here we have the printed abbreviations *Pes., ps, pe, p.* More interesting and convincing are the abbreviations found in manuscripts which record commercial transactions. We can give only a small part of the number actually seen. In our selection we are not discriminating against symbols which might suggest a conclusion different from our own. As a matter of fact, such discrimination would be difficult to make, for the reason that all the abbreviations for the "peso," or "piece of eight" or "piastre" that we have examined point unmistakably to only one conclusion. We say this after having seen many hundreds of these symbols in manuscripts, antedating 1800, and written in Mexico, the Philippines, San Felipe de puerto, New Orleans

[14] D. K. Watson, "History of American Coinage," 1899, p. 15.

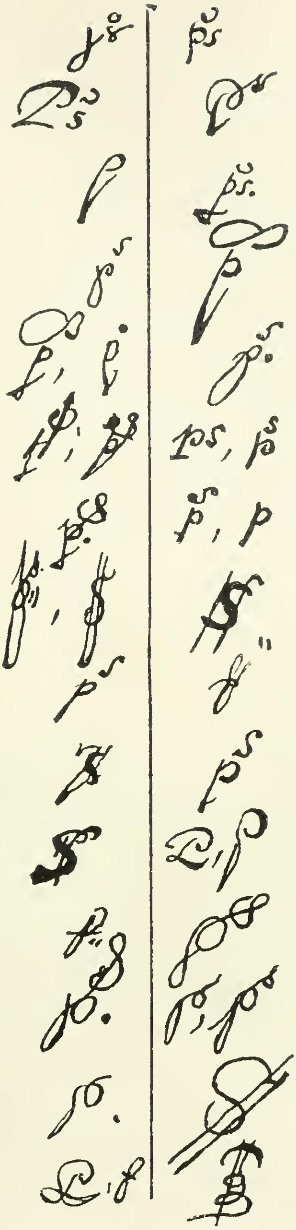
[15] Gordon, "Congressional Currency," p. 118.

[16] Ivan Vasquez de Serna, "Reducciones de oro," Cadiz, 1620, p. 263 ff. (In the Hispanic Museum, New York City.)

[17] Don Fr. Cassany, "Arithmetica deseada," Madrid, 1763. (In the Library of Congress.)

[18] Don Benito Bails, "Arismetica," Madrid, 1790. (In Library of the American Philosophical Society, Philadelphia.)

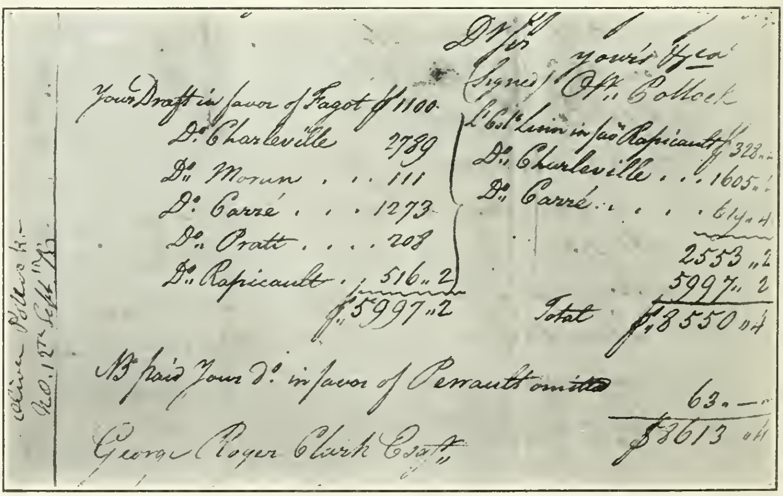
[19] Don M. A. Valdes, "Gazetas de Mexico," 1808. (In Newberry Library, Chicago.)



	Place of MS.	Date of MS.	Date of MS.	Place of MS.	
1	Spain	abt. 1500	1598	Mexico City	2
3	Mexico (?)	1601	1633	San Felipe de puerto	4
5	Mexico	1644	1649	Mexico City	6
7	Manila	1672	1696	Mexico	8
9	Mexico	1718	1746	Mexico City	10
11	Chietla (Mexico)	1748	1766	Manila	12
13	Mexico	1768	1769	?	14
15	New Orleans	1778	(1778) 1783	New Orleans	16
17	Mexico City	1781	1786	New Orleans	18
19	On the Mississippi	1787	1787	Mexico City	20
21	Philadelphia	1792	1793	"Nouvelle Madrid" (N. O.)	22
23	"Nouvelle Madrid" (N. O.)	1794	1794	"Nouvelle Madrid" (N. O.)	24
25	"Nouvelle Madrid" (N. O.)	1794	1794	"Nouvelle Madrid" (N. O.)	26
27	New Orleans	1796	1796	Philadelphia (?)	28
29	New Orleans	1796	1799	Louisville (?)	30

FIG. 3. SYMBOLS FOR THE SPANISH DOLLAR OR PESO, traced from MS. letters, contracts and account-books. No. 1. The historian, Dr. Cayetano Coll y Toste, of Porto Rico, says that this was the written symbol "during the time of Christopher Columbus." Nos. 2, 3, 6, 9, 10, 11, 13, 14, 17, 20 are traced from MSS. owned by W. W. Blake, Avenida 16 de Septiembre 13, Mexico City. Nos. 15, 16, 18, 19 are from Draper Coll. in Wis. Hist. Libr., Madison; Nos. 15, 16 in Clark MSS., Vol. 48 J, pp. 37, 38; Nos. 18, 19 in Clark MSS., Vol. 1, pp. 136, 143. Nos. 4, 5, 7, 8, 12 are from the Ayer Coll. Newberry Libr., Chicago. No. 21 from letter of Robt. Morris to the Hon. Jeremiah Wadsworth, Esq., Hartford, Conn., in Harper Mem. Libr., University of Chicago. Nos. 22, 23, 24, 25, 26, 27, 28, 29, 30 are from MSS. in Chicago Hist. Soc. Libr.; No. 22 in Menard Coll., Vol. 64; Nos. 23, 24 in Menard Coll., Vol. 60, p. 187; Nos. 25, 30 in Autogr. Letters, Vol. 61; No. 26 in Menard Coll., Vol. 62; Nos. 27, 29 in Menard Coll., Vol. 63; No. 28 Autogr. Letters, Vol. 71, p. 76.

and the colonies of the United States. It was a remarkable coincidence that all three names by which the Spanish dollar was best known, namely the "peso," "piastre" and "piece of eight," began with the letter *p* and all three were pluralized by the use of the letter *s*. Hence *p* and *ps* admirably answered as abbreviations of any of these names. The symbols in Fig. 3 show that the usual abbreviation was a *ps* or *p*, the letter *p* taking sometimes a florescent form and the *s* in *ps* being as a rule raised above the *p*. The *p* and the *s* are often connected, showing that they were written in these instances by one uninterrupted motion of the pen. As seen in Fig. 3, the same manuscript sometimes shows symbols of widely different shapes. The capital P is a rare occurrence. We have seen it used at the beginning of sentences and a few times written in ledgers at the top of columns of figures. In the sixteenth century the *ps* had above it a mark indicating the omission of part of the word, thus *p̃s*. Sometimes the contraction of the word "pesos" was "pss." or "pos." Not infrequently two or more different abbreviations are found in one and the same manuscript. The body of the text may contain the word written out in full, or contracted to "pss" or "pos," while the margin or the head of a column of figures may exhibit *ps* or simply *p*. These were the abbreviations used by the Spanish-Americans from the sixteenth century down to about 1820 or


Your Draft in favor of Fagot ƒ 1100
Do. Charleville 2789
Do. Morun . . . 111
Do. Carré . . . 1273
Do. Pratt . . . 208
Do. Rapicault . . 516„2
ƒ 5997„2

yours &c.
(Signed) Oll. Pollock
L. Col. Linn in fav. Rapicault ƒ 323„
Do. Charleville . . . 1605„
Do. Carré . . . 614„4
2553„2
5997„2
Total ƒ 8550„4

N.B. paid your Do. in favor of Perrault omitted 63„—
ƒ 8613„4
George Roger Clark Esqr.

Fig. 4. The Modern Dollar Mark in the Making. From copy of letter by Oliver Pollock at New Orleans to George Roger Clark, 1778. (Wis. Hist. Libr., Madison, Draper Coll., Vol. 38 J, p. 37.)

1830. The transition from the *ps* to our modern dollar mark was not made by the Spaniards; it was made by the English-speaking people who came in contact with the Spaniards. At the time when Mexico achieved its independence (1821), the $ was not yet in vogue there.

In a Mexican book of 1834 on statistics[20] both the *ps* and the $ are used. Our $ was introduced into Hawaii by American missionaries, in a translation of Warren Colburn's "Mental Arithmetic" in 1845.[21]

The transition from the florescent p^s to our dollar mark is seen in Fig. 4. Apparently it is a change introduced unconsciously, in the effort to simplify the complicated motion of the pen called for in the florescent p^s. No manuscript on this point is so interesting and convincing as the two contemporaneous copies, made by the same hand, of a letter written in 1778 by Oliver Pollock, then "commercial agent of the United States at New Orleans." Pollock rendered great services to the United States, being to the west what Robert Morris was to the east. Pollock's letter is addressed to George Roger Clark, who was then heading an expedition for the capture of the Illinois country. Both copies of that letter show the $ in the body of the letter, while in the summary of accounts, at the close, the $ and the florescent p^s are both used. These documents show indeed "the modern dollar mark in the making." In the copy from which our photograph is taken, Fig. 4, the 8613 dollars is indicated by the regular $, while in the other copy it is represented by the fancy p^s. Carefully examining the two symbols in our photograph, we see that the p^s is made by one continuous motion of the pen, in this order: Down on the left—up on the right—the loop of the *p*—the *s* above. On the other hand, the $ symbol is made by two motions: One motion down and up for the *p*, the other motion the curve for the *s*, one symbol being superimposed upon the other.

Thus the origin of the dollar mark is simplicity itself. It is an evolution from p^s. When the *p* was made by one long stroke only, as in Fig. 3, Nos. 12, 14, 17, 20, then the $ took the form $, as used by Robert Morris (Fig. 3, No. 21). Before 1800 the regular mark $ was seldom used. In all our researches we have encountered it in eighteenth-century manuscripts not more than 15 or 20 times. None of these antedates the ones in Oliver Pollock's letter of 1778. But the dollar money was then very familiar. In 1778 theater prices in printed advertisements in Philadelphia ran, "Box, one dollar." An original manuscript document of 1780 gives 34 signatures of subscribers, headed by the signature of George Washington. The subscribers agree to pay the sum annexed to their respective names, "in the promotion of support of a dancing assembly to be held in Morristown this present winter." The sums are given in dollars, but not one of the signers used the $ symbol; they wrote "Dollars," or "Doll," or "D^s."[22]

[20] "Noticias estadisticas del Estado de Chihuahua," par J. A. Escudero, Mexico, 1834.

[21] Copy in the Newberry Library, Chicago.

[22] "American Historical and Literary Curiosities," Philadelphia, 1861, plates 52, 22.

It is interesting to observe that Spanish-Americans placed the *ps* after the numerals, thus 65*ps*, while the English colonists, being accustomed to write £ before the number of pounds, wrote the $ to the left of the numerals, thus $ 65. In the Argentine Republic the $ is to this day written to the right of the numerals, like this 65$.

The earliest known occurrence of the $ *in print* is in an American arithmetic, Chauncey Lee's "American Accomptant," published in 1797 at Lansingburgh. This fact was pointed out in 1899.[23] A recent writer[24] again calls attention to this arithmetic and then, with sweet simplicity of mind, conveys the idea that this publication constitutes the true origin of the dollar mark. By this mental short cut he saved himself the drudgery of a research which, in our case, has extended over several years. After 1800 the symbol began to be used freely, both in print and in writing. On September 29, 1802, William A. Washington wrote a letter on the disposal of part of the bottom land above the Potomac, belonging to the estate of George Washington. In this letter there is mention of "$20," "$30" and "$40" per acre.[25]

In this article it has been established that the $ is the lineal descendent of the Spanish abbreviation p^s for "pesos," that the change from the florescent *p*^{s} to $ was made about 1775 by English-Americans who came in business relations with Spanish-Americans, and that the earliest printed $ dates back to the year 1797.

[23] "Report of the Commissioner of Education," 1897–98, p. 811.

[24] *Bankers' Magazine*, Vol. 62, 1908, p. 857.

[25] Letter in Harper Memorial Library, University of Chicago.

PRACTICAL FORESTRY EXPLAINED

By Gen. C. C. Andrews

formerly forestry commissioner of minnesota

FORESTRY is the science of deriving a sure and fairly good revenue from the production of valuable timber trees on such hilly, rocky or sandy land as is unfit for field crops. The pine takes from the soil only a twelfth part of the mineral matter that is required for field crops. Air and light are its principal food.

The average net income from the German state forests is about three per cent. per annum. The average value of the land containing the forest is about $150 per acre. Much of the land is mountainous.

A normal forest is one from which enough trees can be cut annually for revenue, without impairing the capital. The forest crop has this advantage over field crops that it is not absolutely necessary to cut it at any particular time, but that the cutting can be at a time that will best suit the market. If we had a natural or virgin forest of considerable extent, we should find in it trees of various sizes and ages. (In the Minnesota National Forest, December, 1906, a white pine was cut that was 425 years old, six feet in diameter breast high, and which yielded 6,200 board feet.) If our natural forests were handy to a permanent railroad or the logs could be floated from it by water to a saw-

What Forestry Science does. A German forest of spruce planted and managed according to forestry science; trees about eighty and one hundred years old.

A Natural Forest of White Pine in Minnesota.

mill, we could every year cut the more mature trees, leave the younger ones to grow, and in reasonable time bring it into a normal forest. Usually, however, natural forests are remote from established lines of transportation, and the lumberman who handles them must construct temporary logging railroads which are taken up when the timber has all been cut. He has invested his money, expecting to get it back soon with a profit and can not wait for trees to grow. He usually cuts clean as he goes. He can not afford to practise forestry and no reasonable person expects him to do so. It would take too long for nature unaided to renew forest. Natural reforestation has as good a chance in Germany as anywhere because fire there does little damage. But Germany plants over a hundred thousand acres of forest annually.

If we were to start an artificial pine forest it would be by planting seedlings—nursery grown trees—two years old, four feet apart, requiring at that rate 2,722 seedlings per acre. If land we purpose using happens to be part of an abandoned farm or is land from which natural forest was cut twenty or thirty years ago, probably five per cent. of the area is already well stocked by nature with valuable kinds of timber trees. Probably another five per cent. of the area consists of rocks or wet places that can not be planted, so that only ninety per cent. of our area will require to be planted.

Why should trees be planted as close as four feet? To get the ground shaded as soon as possible, to promote moisture and fertility; also to promote height growth. In a crowded forest the shade causes the trees to shed their lower limbs. It is only in this way that long smooth logs, free from knots, are produced. Every one has seen that a tree in the open grows too many branches to make good timber. In a

forest that is crowded when young, a natural thinning occurs as it develops. The weaker trees die out. An average acre of mixed woods in the Black Forest of Germany, which at the age of twenty years contained 3,960 trees, contained at the age of forty years 1,013 trees and at the age of eighty years, 346 trees.

A person intending to start a forest should plant the trees in the spring as soon as the frost is out of the ground. The most economical plan probably will be to buy them of a reliable nurseryman. The forestry departments of some states now furnish seedlings at cost. In 1910 the Superintendent of Forests of the state of New York supplied to private parties at cost 2,733,200 trees, being mostly white pine seedlings two years old. The pine produces a crop of cones every two or three years, and if conditions are very favorable, one might gather the cones, which should be done about the first part of September. By drying them in the sun, the seeds can be shaken out. The seeds should be kept in a cool safe place, and can be sown in the spring in a garden bed in the same way that garden seeds are sown, and the first summer must be protected from the sun by lath screens about two feet above the beds, or by an arbor of boughs ten feet high. In muggy weather, the delicate pine plant is liable to a blight called "damping off" and as a preventative should obtain good air currents. When ready for planting they should be carefully taken up with a spade, not pulled up. The roots must not be exposed to the sun at all. The plants must be car-

NON-AGRICULTURAL LAND, FROM WHICH WHITE-PINE FOREST HAS BEEN REMOVED.

ried to the place of planting in pails of mud. The holes in which they are to be set should be made with a grub hoe or light spade, the soil pulverized, and in planting the roots should be given their natural position, the soil firmed around them, and they should be set two or three inches deeper than the surrounding surface. A young forest should have the sides that are exposed to the prevailing winds more densely planted than elsewhere; wind being one of the forest's worst enemies.

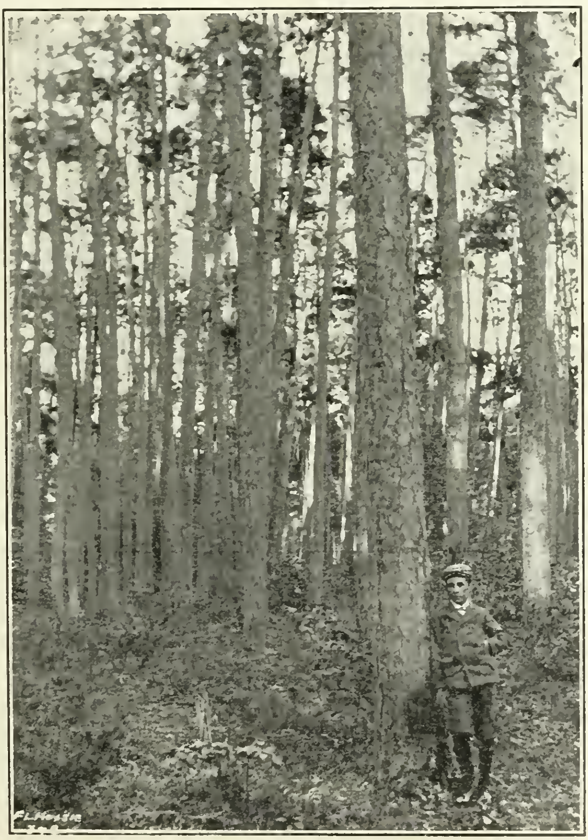
In planting a small tract of even five acres, there may occasionally be a small piece of ground such as the bottom of a ravine, with soil fertile enough to sustain hardwood trees such as the sugar maple, ash, chestnut or oak, and if so, such kind of trees had better be planted, both to improve the appearance of the forest and to attract birds. Two men

Natural Reproduction of White Pine, twenty-five feet high and six to eight inches in diameter, on the Daniel Webster farm at Marshfield, Mass. Grown from seed of pines that were planted by Mr. Webster eighty-six years ago. (Photographed August, 1902.)

can work well together. The first digs the hole; the other, following with the young trees, plants the tree. If the job is large, quite a number of men may be employed; in such case, the two men who started the first row should keep two trees in advance of the men on their right. Two men can plant 1,400 trees in eight hours.

Pine grows very slowly the first ten years, but afterwards rapidly up to about its eightieth year; after that it will grow for two centuries or more, but too slowly to earn good interest on the capital it repre-

Natural Forest of Norway (red) Pine (*Pinus resinosa*), on the White Earth Chippewa Indian Reservation in Minnesota.



A Natural Forest of Norway (red) Pine in Minnesota.

sents. In a pine forest, therefore, intended for revenue, eighty years is generally considered the fiscal age of the trees. To derive good revenue the trees should be cut at about that age, at which time they will have reached on an average a diameter of thirteen inches breast high. After removal of the timber where natural regeneration does not prevail, the blank spaces must be planted.

If the forest is extensive one would need in due time to have a skilled forester make a map of it and a working plan, showing the character of surface and soil, location of roads and trails; kinds, localities and age of trees, and all other facts indicating the work necessary to be done to maintain a sustained yield. The forest should be fenced as animals do injury to trees. After a forest crop has been cut enough of the brush to prevent future danger should be burned at a safe time by piling it upon a fire. Fire in a forest should never be allowed to run nor left to smoulder.

A good rule for estimating the number of board feet in a tree is this one, called Doyle's: from the average diameter in inches deduct 4 (as representing slabs); square one quarter of the remainder and multiply by length in feet. For example, suppose a tree is 65 feet high and its average diameter 16 inches; deduct 4 leaves 12 inches, one quarter of which is 3, which squared makes 9; this multiplied by the height of the tree, 65, gives 585 board feet as the contents of the tree.

We have thus seen that by forestry, refuse land can be converted into interest yielding capital as good as government bonds.

In a normal forest the average annual growth on third and fourth rate land amounts to about 280 feet board measure per acre. At that rate we shall expect that our planted forest of red (Norway) and white pine would in eighty years contain on an average 22,000 board feet per acre of merchantable timber, a fairly conservative estimate. I have seen on my native farm in New Hampshire white pine grow to a diameter of two feet breast high in fifty years, but it was on fresh loamy soil, such as is most favorable for the white pine.

We can assume that the expense of planting per acre will be as follows: cost of land, \$5, trees, \$6, planting, \$10, total, \$21, being the capital invested in one acre of forest. This sum at 3 per cent. compound interest will amount in eighty years to \$223.44. The price of pine stumpage in this country has trebled in the past twenty years, and we can very safely assume that in eighty years its value will at least be \$20 per thousand board feet. The acre crop of 22,000 board feet will then be worth \$440, so that the average acre of forest will have yielded a net revenue of 3 per cent. on the capital invested, and left a surplus of \$216.56 which will have paid the expense of management and taxes. There will also be a little revenue from thinnings and from game.

INSECTS AS AGENTS IN THE SPREAD OF DISEASE

By CHARLES T. BRUES

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LESS than fifteen years have elapsed since the scientific world entertained its first definite suspicion that certain human diseases might be spread through the agency of insects. Twelve have gone by since that suspicion became an established fact, and in this short space of time so much has been learned concerning the pernicious activities of these small animals in disseminating disease-causing organisms among man and the higher animals, that the science of preventive medicine can now be applied to many important diseases which were before utterly beyond its reach. Every year brings forth fresh evidence that insects are important factors in relation to public health, and adds to the list of diseases that are partially or entirely dependent upon certain insects for their spread.

A brief statement of the nature of communicable diseases and of the general habits of the kinds of insects that are implicated in carrying disease will serve to define roughly the field of medical investigation which is open to the entomologist. Communicable diseases are invariably due to parasitic organisms in the body which are capable of inducing similar symptoms in other persons or animals if transferred to healthy individuals from diseased ones. Many conditions modify the transfer of communicable diseases; some individuals are more easily infected than others; some may be immune as the result of a previous attack; and, on the other hand, the virulence of pathogenic organisms often varies greatly in accordance with conditions to which they have been subjected previously. A simple method of spread occurs with many diseases, for example typhoid fever and pulmonary tuberculosis With the former, the *Bacillus typhosus* which is the disease-producing organism, is present in the dejecta of an infected person and may find its way from these to food, carried by flies or otherwise; ingested by a healthy person, it may quite likely multiply and induce a second case of typhoid. With tuberculosis, the tubercle bacillus from desiccated sputum may enter the lungs of a healthy person with dust and there reproduce the disease. As we shall see later, certain insects are commonly associated with the spread of diseases of this type, although from the very nature of such diseases, insects are not exclusive factors, and may be referred to as contaminative carriers.

A second type of communicable diseases differs from the one just

mentioned in that the organism which causes the disease must live for a time in the body of some other animal to undergo certain definite changes before it can again induce the disease in another individual. The most important insect-borne diseases belong to this type, for in the case of man and domestic animals, certain insects and ticks act as the secondary host animals for the organisms of many diseases. Thus, yellow fever is spread only through the agency of a certain mosquito, for in its body alone can the yellow fever organism live and undergo the changes that are necessary before it can be introduced into another patient by the bite of an infected mosquito. Malaria belongs to the same category, for it spreads only through the bite of certain mosquitoes that obtain the organisms with their meal of blood, and then afterwards inject into the blood of another person, a later stage of the malarial parasite which has developed meanwhile within the mosquito.

Diseases in which certain insects act as specific carriers are most numerous and prevalent in the warmer parts of the world, although temperate regions are by no means free from diseases of this kind, which may be referred to as the inoculative type.

Among insects which disseminate pathogenic organisms without any specific association, the common housefly is without doubt the most important. The rank of the fly in this unenviable profession is due to several facts in its life-history which render it eminently suited to act as a vector for several diseases such as typhoid fever, diarrhœa, dysentery, summer complaint of children, etc. The eggs of the house fly are laid preferably in horse manure, upon which the larval stages or maggots feed, but human excrement serves equally well, and when exposed is very likely to provide food for a brood of fly maggots. Less than two weeks are required for the larvæ to mature, and after a short resting stage of two or three days the adult flies emerge from their bed of filth. At this time they may quite possibly bear in their alimentary tract bacteria derived from their larval food. Usually, however, they are quite clean when hatched, in spite of the surroundings whence they have come. They do not long remain so, however, for they feed upon animal and human dejecta of all sorts, garbage and other fermenting material, and if still hungry invade markets or houses, where they may leave upon food any bacteria brought upon their bodies, legs, mouth parts or wings. In addition, their excrement deposited as "fly specks" may contain virulent pathogenic bacteria, if they have had access to matter from which these could be obtained.

This, in brief, is the status of the house fly as a disease carrier and it is readily seen why filth diseases are the ones naturally spread by this insect. Attracted to the nursing bottle or to the baby's mouth they may infect him with bacteria of any of the numerous enteric troubles known as summer complaint. If they have had access to the dejecta of a person

suffering from typhoid fever, or to those of a chronic carrier of this disease, they may deposit the virulent bacteria upon food that later finds its way into our own bodies. Bacillary dysentery may be spread in the same fashion as well as many other gastro-enteric infections.

The house fly occurs practically throughout the entire civilized world and under all conditions is a continual menace to public health. In rural communities, however, where the proper disposal of waste matter of all kinds is most difficult, the importance of these insects is correspondingly increased.

The house fly is not the only insect which may act as a carrier of typhoid, for Dutton has shown experimentally that this may be spread by the bed-bug. These insects become infected through feeding on the blood of a person in the acute stage of the disease and for at least twenty-four hours retain the bacteria in a sufficiently virulent condition to inoculate a second person whom they may bite. That other biting insects such as fleas and mosquitoes may act in the same way is as yet unproved, but is by no means improbable.

Several other species of flies appear regularly in houses, but in far lesser numbers, and none exhibit to such a marked degree the peculiar tastes of the house fly, which wanders back and forth from filth to food, feeding on each in turn. In this method of feeding lies the danger of infection by house flies; they are equally fond of clean and filthy materials, and their frequent migrations from one to the other multiply their opportunities to pick up pathogenic organisms that may be later deposited upon foods.

The flea is another domestic insect which was looked upon only as a nuisance until it was shown that certain kinds of fleas are agents in spreading bubonic plague. The most terrible epidemics of which we have any historical record have been those of plague, or "black death." One swept from Egypt in the sixth century before the Christian era and invaded Europe and Asia, where it raged for sixty years. A similar one spread through the whole known world in the fourteenth century and is thought to have caused over twenty-five million deaths before it subsided.

In 1898 Simond suspected fleas as agents in the spread of plague and his suspicions have since been fully justified by Verjbitski and others. Plague is common to rats, certain other rodents and man, and is usually carried to man by the bites of fleas which have become infected from plague-stricken rats. The flea most commonly concerned is the rat flea, *Lœmopsylla cheopis.* The transfer of plague bacteria is mechanical in nature, and other fleas, bed-bugs, etc., may also act as carriers, although far less commonly.

The plague bacilli (*Bacillus pestis*) appear only in fleas and bugs which have bitten affected persons or rats twelve to twenty-six hours

previous to death, for after this time the bacilli do not occur in the blood. The vitality and virulence of the bacilli are preserved for nearly a week at least and sometimes fully a month; and there is actually an increase in their number during the first few days. Infection from these insects may then occur through their bites, if they contain extremely virulent bacilli, but probably occurs more commonly by the insects being crushed *in situ* after they have punctured the skin. Plague is confined more generally to the tropics and in recent years has threatened to become epidemic in the United States only in the region bordering San Francisco, Cal. Prompt measures of repression, based on a knowledge of the manner in which the disease spreads, have, however, been very successful and future wide-spread epidemics are not to be expected.

Plague is primarily a disease of rats, and its occurrence as a human disease is rather secondary, so nearly so that it can almost be said "no rats, no plague." On this account the destruction of rats is the first prophylactic measure to be undertaken for the suppression of plague, since this is much more readily accomplished than the destruction of the fleas directly. In parts of California the wild ground squirrel has become infected with plague from rats and presents a menace to the human population, although apparently not so great a one as the rat.

Another disease that has very recently been demonstrated to be insect-borne is typhus fever. This should not be confused with typhoid; it is a very different disease, occurring in the tropics and colder regions alike, and usually associated with dirty, unsanitary surroundings. On this account, it is becoming less prevalent in civilized countries every year, but has at times in the past claimed many victims. During our own civil war, the inmates of army prisons suffered greatly from the ravages of typhus fever, and similar conditions of crowding many people together in filthy surroundings have long been known to be favorable for the development of typhus fever epidemics. We now know through the researches of Ricketts and others that typhus is carried by vermin, the body louse, *Pediculus vestimenti,* acting as the vector. Thus the etiology of typhus has suddenly been made clear and we are in a position to formulate measures for prophylaxis and quarantine which will prevent the development of the disease in epidemic form. There is much yet to be learned; perhaps other insects also may act as carriers, but there can be no doubt that typhus is almost exclusively insect-borne.

Another disease which has puzzled the medical profession for centuries is a peculiar malady known as pellagra. Pellagra develops very slowly, and the origin of individual cases is correspondingly difficult to trace. It is also usually rather erratic or sporadic in occurrence, but appears to be rapidly increasing in prevalence in many parts of the United States. At one time it was thought that pellagra was contracted

through eating moldy corn or corn products, and investigators went so far as to describe a certain fungus as the specific cause of the disease. This hypothesis was never satisfactorily in accord with the facts, and has been abandoned very generally in favor of a belief that pellagra is insect-borne. This has not yet been sustained by actual proof, and is far from being generally accepted, but Sambon and others have adduced much evidence to show that the "black-fly" (*Simulium*) may be the carrier for the virus of pellagra. These flies are widely distributed throughout the world, always occurring in proximity to rapidly flowing streams of water in which the larvæ live. The adults, though small, are vicious biters. They appear mainly in the spring, more rarely in the fall, and agree in seasonal distribution with the incidence of pellagra. The causal organism has never been found and is evidently an ultra-microscopical or filterable virus.

One of the best known insect-borne diseases, and one which is of great importance in many parts of our own country is malarial fever, variously termed ague, chills and fever, etc. This was the first human disease traced directly to insect carriers and gave the impetus which has led to the unraveling of the facts connected with other insect-borne diseases. There are many types of malarial fevers, due to a number of similar but different blood parasites and the disease is most common in tropical regions, although in our own country it extends well into the northern states, even quite commonly into Massachusetts. The protozoan blood parasites that cause malaria were first demonstrated many years ago, in 1880, by a French surgeon, Laveran, who discovered them in the blood of persons suffering from malaria. Five years later an Italian, Golgi, distinguished three kinds, each associated with one of the more familiar types of malaria. They were found to go through a regular life cycle in the red blood corpuscles and, from analogy with other known Protozoa, it was suspected that in addition to their non-sexual generations in the human blood there must be a sexual development in some cold-blooded animal. Manson was led to suspect that some insect might be the secondary host and, working on this hypothesis, Ross in India first found the malarial parasites in a certain kind of mosquito in 1898. He had worked for nearly three years on a common mosquito belonging to the genus *Culex* without result, but finally in a mosquito of the genus *Anopheles* was able to trace the development of the parasite. His epoch-making discovery has been since amply confirmed and extended by experimental proof till we now know that the various types of malarial blood parasites complete their life-cycles in anopheline mosquitoes, the latter acting as the sole carriers of the disease.

The details of growth and development of these parasites, which belong to the Protozoan genus *Plasmodium,* are extremely interesting, but far too complicated to discuss briefly. In general it may be said

that the blood of persons suffering from malaria contains the parasitic organisms, and that these, on being taken into the stomach of the proper kind of mosquito, undergo certain changes and later penetrate the wall of the stomach to form vesicular swellings. Within these they multiply, and finally on the bursting of the nodule are set free in the body cavity and find their way to the salivary glands. After becoming infected, a period of twelve to twenty days are required for these changes in the mosquito. Then for a period of several weeks the virulent organisms remain in the salivary glands and if the mosquito bites a second person the parasites are introduced with the salivary secretion, through the puncture into the circulation. Here they multiply and produce another case of human malaria, which develops from ten days to three weeks after inoculation.

As previously stated, only certain mosquitoes can transmit malaria, for when the parasites are ingested by other species of mosquitoes they do not continue their development, but die without passing through the stomach into the salivary glands. In the United States only one form, *Anopheles maculipennis*, is capable of harboring malaria, but in other parts of the world, especially in the tropics, other species of *Anopheles* and related genera act as hosts for the several kinds of *Plasmodium*.

Although in temperate regions the number of deaths from malaria is rather small, in spite of the wide-spread occurrence of the disease, the economic loss is very great, due to the debilitated condition which invariably occurs in the population of malarial districts. In the tropics, however, malaria in its various forms causes an enormous number of deaths and predisposes its victims to so many other dread diseases that it ranks as perhaps the most important human disease.

Fortunately prophylactic measures against malaria are not difficult, although they have been shamefully neglected in our own country. They consist in the elimination of anopheline mosquitoes, which is best accomplished by the destruction of mosquitoes in general. The larval or preparatory stages of anopheline, and of practically all other mosquitoes, are passed in the water of small quiet ponds, puddles, exposed vessels containing water, rain-barrels, etc., and it is during this period that they are most easily controlled. This is accomplished by oiling the water with either crude or refined petroleum or with some miscible oil. The petroleum forms a film over the surface of the water through which the larvæ can not extrude their breathing tubes and they are thus suffocated. The application of miscible oils is efficacious, but attended with some danger, since it destroys fish and predatory insects which are themselves some of the most important natural enemies of mosquitoes. Very frequently even oiling is not necessary, as much swamp land may be permanently freed from mosquitoes by very simple systems of drainage ditches which prevent the accumulation of the stagnant water in which the larvæ occur.

Anti-malarial work of this sort has been undertaken and successfully prosecuted in many parts of the world; in the Federated Malay States, in the Suez Canal region, at Havana, Cuba, and in the Panama Canal Zone. Many other regions might be mentioned, but we must look in vain for such concerted and sustained work in the United States. Attempts have been made by many entomologists and public-spirited citizens to inaugurate measures against mosquitoes on account of their relation to malaria, but with the excepion of the most successful work accomplished by Smith in New Jersey and by others on Long Island little has been done to aid the efforts of the energetic few. We have, however, reason to believe that such apathetic contemplation on the part of the American public will some day develop into an active interest, and that the population of our extensive malaria-ridden areas will gradually see the possibilities of improvement in public health through the destruction of the malarial mosquito.

Another mosquito-borne disease which has aroused more interest in America on account of its spectacular appearance and higher mortality is yellow fever. This is due to a filterable virus, concerning the nature of which we can only speculate at the present time, although enough has been ascertained through experimental work to demonstrate that the virus is a living organism which undergoes a development of definite periodicity in mosquitoes of a single species known as *Stegomyia calopus*. This mosquito enjoys a very wide distribution in many parts of the world, mainly in the tropics, but also extends into the warmer temperate regions. Yellow fever is not so extensively distributed, being absent in many places where *Stegomyia* occurs, but it is nevertheless present in many parts of the tropics in both hemispheres and all that is necessary for the development of a possible epidemic in a region where *Stegomyia* occurs is the introduction of a human case in the early stages of the fever.

The larval habits of *Stegomyia* are in quite marked contrast to those of *Anopheles*. The adults are strictly domestic mosquitoes and occur almost entirely in the neighborhood of human habitations. Their larvæ occur in the same places, breeding preferably in vessels containing small amounts of water, rain barrels, cisterns, stray tin cans filled with rain water, etc. On this account, extermination work against the yellow-fever mosquito resolves itself mainly into the examination and treatment of cities, towns and the immediate environment of smaller settlements.

A *Stegomyia* feeding upon the blood of a person suffering from yellow fever becomes infected only during the first three or four days after the onset of the fever; later than this mosquitoes do not obtain the virus. An incubation period of at least twelve or fourteen days in the mosquito is now necessary before the mosquito can infect a second

person, after which the *Stegomyia* remains infectious for a long period and may be responsible for a series of new cases. These facts were first discovered during the summer of 1900 by a Yellow Fever Commission consisting of Drs. Reed, Carroll, Lazear and Agramonte, of the U. S. Army. Two of these men, Carroll and Lazear, allowed themselves to be bitten by infected mosquitoes, and Lazear died from a severe case of fever thus contracted.

Little further has since been learned of the etiology of yellow fever, but wonderful strides have been made in the application of these simple facts for its eradication. In Cuba, where the commission conducted their investigations, the first attempts were made, and in 1902 yellow fever had been entirely eliminated in Havana. Other West Indian islands were formerly badly infested with yellow fever, but at the present time there is little more danger from this disease there than in the United States. Rio de Janeiro was once a hot bed for yellow fever, but it too has yielded to the destruction of mosquitoes and the screening of patients, till after a six years' fight, the fever has vanished. Still more remarkable are the results accomplished in the Panama Canal Zone under the direction of Dr. Gorgas. Here the warfare against yellow fever has gone hand in hand with anti-malarial work and the isthmus has been transformed from a veritable death-trap to a condition which compares favorably with that of any region on earth.

Our own country has suffered from yellow fever in the past, mainly in the south, but extending to southern Illinois in 1878, to Philadelphia in the terrible epidemic of 1793 and even to Boston and into interior New England towns in the earlier days. The last epidemic occurred during the summer of 1905 in New Orleans, where the application of rational methods rapidly checked the spread of the disease and resulted in its complete eradication long before cold weather. The success of this campaign has undoubtedly sounded the death knell of the yellow fever epidemic and panic in the United States, for New Orleans has amply demonstrated what may be accomplished in the control of an epidemic by an efficient group of workers, backed by a sympathetic public and supplied with reasonable funds.

Rocky Mountain spotted fever, an important human disease which occurs in certain parts of the Rocky Mountain region in the northern United States, has been shown to be insect-borne. In this case the vector is a tick, not a true insect, but a member of the arthropod group Acarina, whose members are so much like insects in many ways that it is hardly necessary to make any distinction in the present discussion. In 1902 Wilson and Chowning suggested that ticks might carry this disease, and four years later Ricketts definitely proved such to be the case. Spotted fever occurs in its most severe form with 70–80 per cent. mortality in western Montana, but extends into several other near-by

states in a much milder form with only 5 per cent. mortality. A common wood-tick of that region, *Dermacentor venustus,* seems to be the only carrier under natural conditions, but recently Maver has shown experimentally that other ticks can transfer the virus. One of these is *Amblyomma americanum,* a common form in the eastern states, and two others are members of the genus *Dermacentor* which occur also in the east. Whether spotted fever will eventually become established beyond its present range must remain a matter of conjecture, although there appears to be nothing that precludes such a grave possibility.

One of the most important insect-borne human diseases which does not exist in the new world is African sleeping sickness. In recent years this malady has decimated the native population in certain parts of eastern equatorial Africa and any extension of its range would be most serious. It seems very unlikely that America will ever have to face an epidemic, for the introduction of sleeping sickness together with its carrier is not at all probable, and the possibility of its becoming established, even after introduction, is still more remote. As is well known, sleeping sickness depends for its spread entirely upon certain biting flies known as tsetse-flies belonging to the same family as our common house fly and stable fly. The genus *Glossina* in which these flies are included is restricted to the African continent, but is there represented by a number of species, several of which have been shown to act as carriers for trypanosome diseases in animals. One only, *Glossina palpalis,* is known to carry the trypanosome of human sleeping sickness, *Trypanosoma gambiense.* The disease appears to have been originally endemic only in West Africa, but was found in eastern equatorial Africa something over ten years ago, and it is in this latter region that its ravages have been so pronounced. Owing to certain peculiarities in the habits of the tsetse-flies, the distribution of sleeping sickness is limited to very definite areas in the region where it occurs. The fly, which has a sharp needle-like beak for sucking blood, resembles our own stable-fly (*Stomoxys calcitrans*) in general appearance but is considerably larger, measuring about half an inch in length. It is found only in the dense brush which grows along the edges of streams, ponds and lakes. In such places persons and animals may be bitten by the flies and it is exclusively through such bites that these insects may obtain virus of sleeping sickness from the blood of a person or animal suffering with the disease. Should the fly obtain a meal of blood containing trypanosomes, these may multiply in the body of the fly, although not always, for only about one in twenty of such flies becomes infectious. A considerable period must now elapse before the infected fly is in condition to inoculate a new patient, usually thirty or forty days, but after this for at least seventy-five days it remains infectious, and may introduce the trypanosomes into the blood of any animal upon which it feeds during this period.

The tsetse-flies develop in a very different way from most insects. The female does not deposit her eggs, but a single one develops to the fully grown larval condition before being deposited. This larva soon pupates in the shade beneath the brush bordering the water where it has been dropped by the parent fly, and later emerges in the winged adult condition. The pupæ require such moist shade, and it is apparently for this reason alone that the flies never occur away from the immediate vicinity of the water. As a result of its method of development, the tsetse-flies do not multiply rapidly, and under favorable conditions only one larva is produced in a ten-day period.

The trypanosome of sleeping sickness was discovered by Bruce in 1902 and a year later the role of *Glossina palpalis* in its transmission was proved. Since then much energy has been expended in attempting to stamp out the disease by every possible means. It was thought at first, that by moving all the natives back from the edges of the water the flies thus left without opportunities for re-infection, would become free from trypanosomes, and that by isolating and treating cases of the disease in fly-free areas it would be possible to eliminate it entirely. In conjunction with this, the cutting of brush, especially about boat landings and watering-places, has been practised as far as possible. Contrary to expectations, it has been found that even after three or four years, infected flies still occur along the uninhabited shores. This led to experimentation upon animals and it is now known that various wild antelopes as well as certain domestic animals may act as reservoirs for the virus of sleeping sickness which may thus persist in the complete absence of any human subjects. As a result of this discovery the great difficulties of combatting the disease among the ignorant African natives have been vastly increased.

The regions surrounding the Mediterranean Sea are the centers of distribution for a very interesting, but far less dangerous insect-borne disease known as phlebotomus fever. In this case the carriers are minute gnat-like flies of the family Psychodidæ known as *Phlebotomus papatasii*. These insects are semi-aquatic in the larval condition, occurring in damp situations, drains, cellars, etc., where they feed on plant matter. The adult is a vicious biter in spite of the fact that it is scarcely over one millimeter in length. It rarely bites except at night, following the habits of certain mosquitoes in this respect. The specific cause of phlebotomus fever is not known, but it has been shown to be an invisible virus. At the present time it is impossible to state whether other insects may play a part in its transmission, although such does not seem probable. We have at least one species of *Phlebotomus* in the United States and it is possible that it might act as a vector should the disease be introduced into our country, although it would seem that such a

possibility would have been realized already if it were likely to occur, for cases of this common European fever must undoubtedly have been imported.

We have already referred to ticks as carriers of spotted fever in this country. Another important disease, or group of closely similar diseases, known as relapsing fever, is known to be tick-borne. This malady is due to a very small spirochæte, a protozoan organism known as *Spirochæta recurrentis*. In acute human cases of this disease these are present in the peripheral blood from whence they may be withdrawn by ticks. Within the alimentary tract of at least some species of ticks the parasites undergo a sort of development which is not well understood, entering the Malpighian tubules or other parts of the body and later assuming a somewhat different spirochæte form. Infection of another person may then occur from a subsequent bite by the infected tick, the virus not passing into the body from the salivary glands or mouth, but entering the wound after having been excreted by the attached tick. As occurs with the tsetse-fly carriers of sleeping sickness, only a part, in this case about one third, of the ticks feeding upon a person with relapsing fever become infected themselves. Of those which do, however, some may transmit the infection to their offspring, which are then capable of infecting man with the virus thus received. Relapsing fever is very widely distributed, mainly in warm countries, although in Europe it has occurred in epidemic form as far north as St. Petersburg. The etiology and method of dissemination of the African type appear to be best known. A common tick, *Ornithodoros moubata,* was first found to act as vector and was until very recently believed to be the only carrier. Now it has been demonstrated that other ticks may act in the same way, and there is a possibility that other carriers may exist, probably in the form of blood-sucking insects.

Relapsing fever has been occasionally reported from the United States, but has never become established.

Among the less important insect-borne diseases is a very widespread tropical fever known as dengue which occasionally spreads into temperate regions in epidemic form. This is due to the presence in the red blood corpuscles of a protozoan smaller than the malarial parasite, probably a spirochæte of some sort. However this may be, we know from experimental tests that dengue may be spread through the agency of certain mosquitoes. The widespread *Culex fatigans* is capable of transmitting the infection and there is good evidence to incriminate the yellow fever mosquito, *Stegomyia calopus.* Dengue is quite common in the southern United States, where in the minds of many people it is confused with malaria. It is less serious, however, although an even more unpleasant ailment to endure.

The same *Culex fatigans* has been shown to be at least partly respon-

sible for the transmission of a parasitic disease of the tropics known as filariasis. The direct cause is a nematode worm belonging to the genus *Filaria* which is present in the circulation and lymphatics of the infected person. In the late stages of the disease the microscopic larval worms occur abundantly in the blood. For some unexplained reason they remain in the deep-seated blood vessels during the day, but usually appear more abundantly in the peripheral circulation during the night. Here they are readily obtained by mosquitoes with their meal of blood. In the alimentary canal of the mosquito the larval *Filaria* discards a sheath-like envelope which has previously invested it, and works its way through the wall of the stomach into the thoracic muscles where it increases greatly in size and finally migrates to the base of the proboscis. From two to three weeks are necessary for this metamorphosis, and for some time longer the *Filaria* may remain in the proboscis awaiting its opportunity to enter another person through the wound occasioned by the mosquito's beak. Once they have been transferred to their human host, the parasites enter the lymphatics where they attain sexual maturity and give rise to the abundant microscopic larval *Filarias* that reenter the circulation to await ingestion by another mosquito.

Filariasis is most common in equatorial regions, but extends less commonly into the subtropics. The parasites themselves do not ordinarily cause great inconvenience, but their presence in the lymphatics may clog these vessels to such an extent that secondary swellings may be developed in the limbs or other parts of the body.

Several insects have been associated with a peculiar tropical disease of the old world, variously known as kala-azar, dum-dum fever and leishmaniosis. In this case the organism is a flagellate protozoan, *Leishmania donovani,* of which there are possibly two forms, one producing a children's disease termed infantile kala-azar and the other the true leishmaniosis of adults. It has been shown that among domestic animals the dog at least is susceptible, and other animals may be also. In 1907 Patton discovered various stages of the *Leishmania* parasites in bed-bugs that had fed on persons suffering from kala-azar and this insect has been considered to be one, if not the exclusive, carrier. Very recently, however, some doubt has been expressed regarding the rôle of the bed-bug and a certain reduviid bug has been suspected. There seems to be no doubt, however, that kala-azar is insect-borne.

The diseases which we have enumerated are the more important insect-borne ones that affect man. A number of others of greater rarity or of minor nature are known to be carried regularly or occasionally by various insects, and many others are now being investigated in the light of present knowledge to ascertain if they, too, may not be spread by insects. It seems probable that flies may take some part in the dissemination of the bacilli of leprosy, although to how great an extent

can not be said, and the same is true to a greater or less degree of cholera, pink-eye, yaws, syphilis, and many other diseases which can not be considered as typically insect-borne.

One other disease which has been increasing at an alarming rate in our own country during the past several decades is infantile paralysis. This malady occurs in certain parts of Europe, whence it is probable that it was brought to America. As a rule it affects children during the first few years of life and, although the mortality is not so very great, a majority of the children affected are left permanently lame after recovery. The virus of this disease is an ultramicroscopic organism which causes lesions of the spinal cord that sometimes lead to paralysis. At the present time it appears probable that infantile paralysis is insect-borne, and it has been suggested by Brues and Sheppard that the stable fly, *Stomoxys calcitrans,* acts as a carrier of the virus,[1] although it is quite possible that some other insect also may be concerned.

No account of insect-borne diseases, however brief, could be complete without some reference to animal diseases. A few of these have already been referred to incidentally as affecting both man and animals, and it is quite likely that other human diseases whose etiology is at present obscure, will in the future be shown to bear some relation to those of animals. Apart from this, the economic loss occasioned by such affections of domestic animals is enormous, although it is in great part preventable.

A wide-spread disease of cattle in the southern part of the United States, known as splenetic fever, or "Texas fever," is the most important insect-borne animal disease that occurs in this country, and is particularly interesting since it was the first disease of any kind shown to be carried exclusively by insects or ticks. It occurs very generally throughout the gulf states as far north as the thirty-sixth parallel of latitude and is the cause of immense pecuniary loss to this region, not only on account of the cattle lost, but as a result of the greatly weakened condition of the animals in general. Southern cattle are usually immunized by an attack at an early age, but northern animals die in large numbers when exposed to the disease.

Smith and Kilborne showed, in 1893, that the protozoan blood-parasite, *Piroplasma bigeminum,* which Smith had discovered several years earlier to be the cause of the disease, is carried by ticks. The common cattle-tick of the southern United States, *Margaropus annulatus,* acts as the exclusive vector, becoming infected during its period of engorgement when feeding on the blood of a diseased animal and then trans-

[1] Since the above was written, it has been shown by experiments with monkeys by Rosenau and Brues, that *Stomoxys* can actually transmit this disease, and their results have been confirmed by Anderson and Frost.

mitting the *Piroplasma* through its eggs to the young ticks of the next generation. These may feed on healthy animals the next season, conveying to them the parasites that have been handed down from the mother tick.

Several similar diseases of cattle occur in other parts of the world. In Africa, related forms of *Piroplasma* carried by ticks are the cause of redwater, East Coast fever, Rhodesian fever, and in various parts of the world other piroplasmoses have been observed in many animals.

Spirochætosis in animals, due to organisms similar to those producing relapsing fever, is well known. The most familiar example is probably a disease of fowls which is carried by *Argas miniatus,* a common tick which infests these birds.

Trypanosomiasis is a general term for diseases like sleeping sickness due to trypanosomes and there are many diseases of this type, among which may be mentioned an old-world affection of horses known as Surra; an African one, Nagana, that attacks other domestic animals as well; and a South American type termed Mal de Caderas. Flies are the insects implicated in the transmission of these diseases, mainly the large tabanid horseflies and the smaller stable flies of the genus *Stomoxys.* Surra was recently introduced into the United States, but was successfully stamped out before it had become established.

Among bacterial diseases of animals, anthrax may be mentioned as one which is sometimes transmitted by biting flies, the insects acting as mechanical or contaminative carriers only.

The foregoing enumeration of insect-borne diseases is by no means complete. Indeed, it would be well-nigh impossible to make it so, in view of the rapid strides which are being made at the present time toward a knowledge of these many problems which bear on the question of public health. New discoveries are being rapidly announced in all parts of the world, and while it is difficult to see how the fundamentally important revelations of the past fifteen years can be equalled in the near future, we should be very unwise to predict that they will not be exceeded.

THE GENESIS OF INDIVIDUAL AND SOCIAL SURPLUS

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LIFE implies surplus energy. No organism can exist for any appreciable period without experiencing the fact that its environment is more favorable or more hostile to its life-activities at one time than at another time. Strength that just suffices to resist some special stress thus yields a surplus when that stress is over. Protozoa and men alike are subject to vicissitudes. At times they barely manage to survive. Again their energy exceeds their needs.

How variations increasing surplus energy are caused no man has definitely shown, though Metchnikoff may yet succeed in proving why the surplus disappears. We merely know that surplus does exist in varying degrees and that its rise and fall depend on measurable facts. We know, too, that the greater the surplus the greater the freedom men have to pursue the higher ends of life or, if they choose, the lower.

The fact that surplus energy exists and that important consequences result therefrom has been often emphasized. Shiller presented the idea in his discussion of esthetics a century ago, and even Groos, though severely criticizing Spencer for connecting the idea of imitation with the overflow of energy, admits the presence of surplus energy to be "the *conditio sine quâ non* which permits the instincts to be so augmented that finally . . . they . . . permit indulgence in merely sportive acts." Patten has even proclaimed a "new basis of civilization" upon the assumption that a social surplus now exists whereby a "pain economy" has been replaced by a "pleasure economy." These writers, however, and others who have dealt with the subject appear to have been interested primarily in demonstrating that certain phenomena or consequences result from an existing surplus. To a limited extent only do they attempt to show upon what conditions the amount of surplus energy in any given case depends. The way appears open, therefore, for a discussion of the clearly marked stages in the increases of surplus energy which have taken place in the evolution of the higher from the lower forms of life and in the evolution of man himself. Such a discussion may be expected to throw light upon at least three problems of more than academic interest. These are the questions: why man in a comparatively brief period of time (as reckoned in geology) has far outstripped competitors; why sociologists should consider psychological

facts of more importance than biological in their interpretations of society; and why it is reasonable, for the present at least, to hold the eugenist's fear of decadence a trifle overdrawn.

Surplus energy, as used in this paper, means the amount of energy available for life-processes which is possessed or obtainable, by any organism, over and above the amount which is necessary for survival at any given time.

Surplus energy, in this sense, assumes many forms. Bodily vigor and long life are not the only manifestations of it. Such material goods, also, as are immediately available for restoration of depleted bodily vigor come under the general heading. Moreover, any structural or other changes in an organism which improve its chances of survival, increase the surplus. The development of useful instincts and the discovery of useful methods of controlling nature and producing wealth—these, too, increase the surplus. Bettered social organization plays its part as well. In fact, in close analysis, every trait and every act of any unit of a group in some way affects the surplus. It is evident, therefore, that only the more important phases of the subject can be considered here. The term social surplus follows directly from the meaning of surplus energy. The social surplus is merely the sum total of surplus energy existing in the individuals composing a social group or immediately available to such individuals.

What were the first steps in the development of surplus energy in the long series of organic changes that led to the evolution of the higher animals and man, none can say. If it is permissible to hold, however, that the earliest ancestors of man were similar in character to the lowest forms of animal life now existing on this planet, we may at least surmise the general character of those early advances.

Consider, for a moment, the great advantage over the lowest protozoa, certain structural differences give that large group of single-celled animals called Ciliata. The microscopic *Amœba proteus,* which may be taken as representative of the very lowest animals, is structurally most simple. Its form is irregular and is continually changing in response to stimulation. Although the internal substance of its body shows some differentiation, there is nothing remotely resembling specialized sense organs. According to Jennings, one of the foremost authorities on the behavior of the lower organisms, the amœba has three characteristic reactions to stimulation. These are, the negative, the positive and the food-taking reactions. The first is a contraction of the part of the animal stimulated when, for example, it comes into strong contact with a solid obstacle. The negative reaction may cause movement in a direction opposite to the point of stimulation. A positive reaction to solid bodies occurs when a pseudopodium is pushed forward in the direction of the stimulus and the animal moves toward the solid. The

negative reaction is useful in avoiding obstacles; the positive in securing contact with food. The food-taking reaction is the enveloping of food by throwing pseudopodia about it. These three reactions together with the ordinary crawling locomotion and the throwing out of pseudopodia in search of a solid on which to crawl, constitute the entire variety of *Amœba's* experiences as displayed in behavior.

The structure of the Ciliata is much more complicated and in certain respects marks a distinct advance in equipment for the struggle for existence. *Paramecium* may represent the type. In this animal not only are the cilia modified locomotory structures, but there is a definite region for food taking. A groove extends obliquely down one side of the body, terminating at its lower end in a mouth. It is to the cilia, chiefly, however, that *Paramecium* owes its superiority over *Amœba*. These are usually inclined backward and their stroke then drives the animal forward. The most interesting characteristic of the stroke is its obliqueness so that *Paramecium* always rotates on its long axis, whether it moves forwards or backwards. In consequence of this fact, according to Jennings, *Paramecium* solves the problem of how an unsymmetrical organism, without eyes or other sense organs, may, nevertheless, maintain a definite course through trackless water. Not even man succeeds in maintaining a straight course under similar but simpler conditions. On the trackless snow-covered prairie the traveler without compass, landmarks or other guide wanders in circles, though it is possible to err only to right or left, not up and down as in the water.

Paramecium, by rotation, compensates for any wandering by equal wandering in the opposite direction. Nature anticipated the modern rifle by several æons. With this equipment whenever a *Paramecium* reacts negatively to some stimulus it is able to continue swimming in a direction away from the stimulus until the stimulation ceases. Through the additional power of slightly accentuating the rotation-swerve the animal is enabled to swim in various directions and to remove itself successively from many different environmental conditions, until it has found what Jennings terms the "optimum." This behavior Jennings characterizes briefly as a "selection from the environmental conditions resulting from varied movements." It is in fact a "trial and error" method with selection of the optimum—a method not unknown to man himself.

This characterization of it, however, may seem to imply too much. *Paramecium* "tries" over and over again, but what is "tried" is always the same thing—there seems to be no profiting by experience. Whether the response of *Paramecium* to stimulation is conditioned in any degree by subjective phenomena, or is even accompanied by them, is a disputed point. Even if present there remains the further question as to the extent such subjective phenomena may be considered similar

to those of the human mind. With respect to the development of surplus energy, however, it matters little whether Jennings's affirmation or Loeb's denial of consciousness is right. It is perfectly clear that the structural change represented by the difference between *Amœba* and *Paramecium* permits greater adaptation of the individual to its environment and, other things equal, tends to permit a greater expenditure of energy in non-sustaining activity. Further improvements in structure encountered as we proceed higher in the scale of evolution likewise imply greater adaptation and still greater surplus.

Before leaving *Paramecium* to discuss behavior of a distinctly more advanced type one more point of special interest to the sociologist must be noted. This is the fact that *Paramecia* in their individual efforts to find the optimum environment are brought into physical proximity. Further, it has been demonstrated that for certain individual *Paramecia* the optimum seems to be created, other things being equal, by the presence of carbon dioxide. Inasmuch as carbon dioxide is produced by the *Paramecia* themselves, this means that such *Paramecia* not only tend to form groups, but indirectly to influence the behavior of each other. If subjective phenomena accompany response to stimulation by carbon dioxide we have here a state of consciousness modified by the presence of organisms of like kind, even if there is, strictly speaking, no consciousness of kind—that is, even if there is no recognition of the presence of another of its own kind by the animal. The formation of groups by *Paramecia* as a result of their own production of carbon dioxide, according to Jennings, explains many peculiar phenomena in their behavior. For example, *Paramecia* in a solution of carbon dioxide react to other agents in a manner entirely different from the action of individuals in water not containing carbon dioxide. Now membership in a group is often an important protection to the individual. It is, therefore, often a factor in survival and is of importance in the production of a surplus.

The important facts to be noted up to this point are, first that change in structure may mean more complex behavior and an increased surplus, and second, that congregation if not association modifies both behavior and safety and this also affects surplus.

In *Stentor roeselii* there enters a new factor affecting surplus. This is the modification of behavior because of past experience. *Stentor roeselii* is a colorless or whitish trumpet-shaped water-inhabiting animal consisting of a slender stalk-like body bearing at its end a broadly expanded disk. The surface of the body is covered with cilia. The smaller end of the body is known as the foot and at this end fine pseudopodia are sent out by which the animal attaches itself. The lower half of the body is surrounded by the so-called tube or sheath formed by a mucus-like secretion from the surface of the body. If, now, some such

substance as carmine ink be introduced into the water so as to reach *Stentor's* disk there are several reactions. At first the normal movements of the cilia which cause a current of water to flow toward the animal's mouth are not changed. The particles of carmine ink enter the mouth and thence penetrate the internal protoplasm. If the cloud becomes dense, however, the animal presently bends aside. If this reaction is not effective in getting rid of the particles it is repeated. If failure still results the ciliary movements are suddenly reversed to produce a current of water away from the mouth. This reversal is brief but, if no improvement is effected, it may be repeated many times in rapid succession. Next, contraction within the sheath may occur. By this contraction the animal escapes stimulation entirely, but it also obtains no food. Usually the animal extends itself again in less than a minute. If particles of carmine are again met *Stentor* no longer reacts in the milder ways employed at first, but contraction occurs at once. This may be repeated many times, each period of retirement lasting longer than the preceding one. Ultimately the animal contracts repeatedly and violently while still encased in its tube. It thus finally detaches its foot from its moorings, leaves its tube, swims away, attaches itself elsewhere and forms a new sheath in a new and more favorable environment.

This behavior differs from that of *Paramecium* in a radical way. *Paramecium,* except when fatigue or other cause reduces surplus energy, always reacts in the same way to the same stimulus. *Stentor* reacts in different ways. As Jennings puts it "the change in reaction must be due to a change in the organism" itself. In any event the present readiness of this organism to react in one of two or more possible ways depends on its past history. The animal profits by experience. The change in reaction is regulatory, not haphazard. Something akin to habit has appeared. This clearly marks the saving of much energy that otherwise would be spent in useless attempts to avoid injurious conditions. There is less waste and more surplus, more chance of survival and a greater length of time during which the animal possesses a surplus of energy over the minimum necessary for survival.

To trace the gradual development of creatures more complex in structure, and in consequence more complex in behavior, might be interesting, but if the recent work of observers of animal behavior is to be trusted no new principles are involved until the primates themselves are approached.

Throughout the period marked by this interval, however, countless changes in the structure, in the production of new reflexes, in the modification of instinctive behavior by the formation of habits, perfected the adjustment of individuals to the physical environment and their accommodation to their fellow creatures. Definite complex com-

binations and series of combinations of reflex reactions in the presence of a series of complex stimulations appeared and these in turn were rendered more complex by the development of habits based on individual experiences repeated anew by every generation. Each useful instinct and every valuable habit made the individual organism more efficient, lessened the effort necessary to live, increased surplus energy.

As man was approached, however, the factor of habit became more and more important. Some hint of how this occurred may be gained from every-day observation. It is a commonplace that exercise of muscles that are fitted to perform certain functions renders the habitual exercise of that function as certain in its operation as is a pure reflex. Young birds awkward in their first flight become expert rapidly. Beasts of prey by trial and error eliminate unsuccessful modes of attack. Before our eyes instinctive actions become modified by experience to a very appreciable extent. Tricks are even taught to seals, lions and elephants, and finally habits useful to man are learned by horse and dog. Thus man has appropriated to his own use the surplus energy developed in the higher animals and has profited thereby immensely.

But the stage of advance now under discussion is that of man's immediate precursors when they, too, had merely learned to profit by past experience through the method of trial and error and elimination of unsuccessful activities.

At this point doubtless the objection will be made that other functions affecting surplus had by this time appeared in man's precursors. It will be held that imitation, at least, was present far down the scale. Certainly it must be granted that any tendency of an organism *A* to imitate a useful innovation of a similar organism *B* would, in most instances, increase the surplus possessed by organism *A*. A flock of birds may take flight if a single bird flies away in alarm. This may be an advantage to every member of the flock. It is necessary, however, to distinguish sharply at least two kinds of imitation. Instinctive imitation, of which the case of the birds which fly when one of the flock takes wing may be taken as an instance, occurs when the sight or sound of one animal's performing a certain act operates as a direct stimulus to the performance of a similar act by another animal whose organization is such as naturally to lead to that act by reflex response whenever the appropriate stimulus is given. The model-act releases the trigger, the organism does the rest by reflex action in accordance with inherited functions. The second type of imitation occurs only when the model-act suggests to the observer the feeling of pleasure or the idea of utility that would result if he repeated the act for himself. The process involved in the first type appears to be no different from those which occur when an animal responds to any stimulus whatsoever. The function is reflex in accordance with the inherited structural organization

of the animal, but becomes modified by the trial and error method.[1] The functioning involved in the second type is radically different from that of the first. It implies the awakening of the impulse to repeat the model-act because of a more or less vivid recognition of its consequences. As Thorndike states it:

> One sees the following sequence: "*A* turning a faucet, *A* getting a drink." If one can free this association from its narrow confinement to *A* so as to get from it the association "impulse to turn faucet, *me* getting a drink," one will surely, if thirsty, turn the faucet, though he had never done so before.[2]

When the second type of imitation, voluntary imitation, appears there is necessarily a tremendous increase in surplus for all social animals possessing it. Thereafter any discovery made by one animal of a group may be transferred by a psychological process to all other animals in the group irrespective of whether they have been accustomed to perform that particular sequence of acts instinctively or not.

A most significant discovery has been made within the past fifteen years in the attempt to ascertain how far down the phylogenetic scale this power of voluntary imitation may be found. This discovery is that man alone possesses it to any considerable degree. Thorndike experimenting with chickens, cats and dogs found no evidence whatever of this type. Even his results with monkeys were, on the whole, negative. Small's rats showed no ability to profit by each other's experience in this way. According to Yerkes this type of imitation plays no considerable rôle in the learning processes of the dancing mouse. Hobhouse, to be sure, holds that cats, dogs, elephants and monkeys were aided in their learning if he "showed" them how to do a thing. Whether this was voluntary imitation, however, or whether the animals were merely aided in focusing their attention on the important object and thus received assistance by lessening the number of trials and errors, is a difficult question to answer. The past experience of the animals, moreover, was not always fully known in these experiments. Kinnaman's monkeys gave more positive results but, as Washburn says, we can not be sure that Kinnaman's monkeys really had an idea of the proper action suggested to them by seeing their companions perform it; the case might have been one of instinctive imitation, taking here a form more elaborate than was seen in cats and dogs because more compli-

[1] "An animal may perform an act the first time because, through inherited nervous connections, the sight of another animal's performing it acts as a stimulus. But it will continue to perform the act, in the absence of any copy to imitate, only if the act is itself an instinctive one, like drinking in birds, or becomes permanent by reason of its consequences, just as would be the case if its first performance had been accidental rather than imitative. As a matter of fact instinctive imitation seems usually to be concerned with actions themselves instinctive." Washburn, "Animal Mind," p. 238.

[2] "Animal Intelligence," p. 50.

cated movements are natural to the monkey than to the lower mammals. Berry also maintains that his experiments "have shown that voluntary imitation of a certain type does exist in white rats" and that "while this imitation is not of as high a degree as that discovered by Kinnaman in his experiments with monkeys, it is not different in kind." He thinks, also, that "a similar type of imitation exists in cats," that "cats to some extent imitate human beings" and that "cats do not instinctively kill and eat mice, but do so by imitation." He holds, however, that "instinctive imitation in cats is more important than students of animal behavior have supposed." Cole (L. W.) thinks he found evidence of voluntary imitation in the raccoon. These results, however, are open to the same objection as that raised against Hobhouse, namely, that the experiments may not have been sufficiently "controlled." In some laboratories efforts to prove the presence of voluntary imitation in the lower animals have been discontinued because of the discouraging uniformity with which negative results have been reached. No one seems to have found indisputable evidence. It is worth noting, however, that the most positive results seem to have been obtained with monkeys. What the experiments have shown unequivocally is that the animals tested learned almost exclusively by a gradual dropping off of unnecessary movements. Upon the nature of this process psychology has thus far thrown little light. Jennings says that the disturbance set up in the organism by the stimulus, by hunger or confinement, not finding an outlet by one path of discharge, seeks others in succession until one is found which relieves the disturbed condition. After repetition the change which leads to relief is reached more directly as "a result of the law of the readier resolution of physiological states after repetition." This "law" is, however, merely a statement of the fact.

It is doubtless true that intermediate stages are present between instinctive and voluntary imitation. Nevertheless, unless the work of expert observers of animal behavior during the past fifteen years is to be overthrown, the assertion may be made that man alone has developed voluntary imitation to any very important degree.

The significance of the advance to the voluntary imitation stage in development is second to none in the whole evolution of organic life for by its attainment human life, as we know it, now became possible.

It has been customary to recognize a more or less definite boundary between man and his precursors based on the development of speech by man. If, as a matter of fact, there is any value in attempting to define the boundary by a single activity, voluntary imitation may be suggested, on the objective side, at least, as of more importance than speech or language. Both voluntary imitation and speech appear to require either conceptual thought or something closely akin to it. Both may thus be taken as objective indices of the existence of that power of abstraction

which the psychologist and ethnologist hold to be a distinctly human trait. Both could have developed only as the power of conceptual thinking advanced. But speech seems to imply the existence of voluntary imitation, whereas the contrary is not necessarily true. The association of a particular sound or even gesture with a particular thing or act is not the only element in speech. There must be the *same* association in the minds of two or more individuals. The simplest way to account for such similarity of association is by the process of voluntary imitation. Doubtless inarticulate cries became signals arousing alertness to stimulation of various sorts long before voluntary imitation had become well-developed. Instinctive imitation had doubtless also created similar cries under similar circumstances, and nothing more perhaps was needed, in some instances, than the recognition on the part of one of two individuals that both used the same cry under the same circumstances, to produce the communication of an idea. The moment, however, an individual desired to make use of this recognition for the purpose of communicating an idea, he must have used the signal-sound as a model, knowing it to be the sound which the other individual associated with the idea he wished to convey. This purposive repetition of the model-sound involved voluntary imitation whether the model was the idea of another individual's cry or that of his own. It is evident, however, that soon after voluntary imitation appeared speech must have begun to arise. But many advances other than speech must have occurred as soon as voluntary imitation appeared. Long before language could have developed to any great extent man must have begun purposively to imitate things other than cries and gestures. The unskilful hunter must have learned new methods from the skilful. The man who discovered that a club was more effective than a fist soon had many followers making use of his invention. In short, voluntary imitation presently entered into every phase of life wherein it became possible to hand down by a psychological process the pragmatically valuable results of the past experience of the race. As soon as voluntary imitation appeared, therefore, the basis was laid for the continuity of history. Speech accelerated development tremendously, but it may be surmised with a considerable degree of probability that voluntary imitation of useful activities was well advanced before man did much talking that "accomplished things."

Doubtless the development of whatever degree of conceptual thinking is required for voluntary imitation was a long and gradual process. A prior stage in which thought was purely in recepts, to use Romanes' term, must have existed for ages. There may prove to have been other prior advances of an importance equal to that of voluntary imitation, the exact nature of which the observer of animal behavior may yet discover, but whatever may be in store in this field, it is certain that

the arrival of voluntary imitation marks the beginning of continuity in human history. Thereafter custom and tradition were possible.

The effect on surplus of the arrival of voluntary imitation is, however, the subject to which the preceding discussion has been merely a preliminary. For the effect on surplus was sufficient to free man to a considerable extent from the domination of purely biological processes and to make progress thereafter, as Professor Ward is continually reminding us, essentially a psychological process. The capital fact is this: whenever, after voluntary imitation appeared, a new discovery or invention was made, that discovery or invention rapidly became the property of the entire group. To whatever extent the relative amount of energy expended for survival was lessened for one individual it was lessened for all. Whatever addition was made to the surplus energy of the discoverer was likewise made to the surplus of all members of the group. Thus the inventors of bow and arrow, of canoe and hoe, immeasurably increased the surplus of society at large. So, from this time forth society increased its wealth, added to the bodily surplus of its members those economic goods which could be easily converted into bodily surplus, developed extra-somatic surplus as well as somatic surplus.

At this point a Malthusian might object that during all the early history of man population tended to increase rapidly enough to keep the surplus of every individual low. Even if this were so, it is nevertheless true that every gain increased the total energy available. A greater population in itself meant a greater total surplus, for, at times, the struggle for existence was suddenly alleviated and at such times the more individuals there were the greater was the sum of human energy freed from the effort to merely maintain existence. Such periods of rapid progress must have occurred many times in history. Every migration into a more favorable habitat, every invention and discovery, has tended to permit the size of human groups to increase and usually has tended to increase longevity as well. The use of fire, the invention of tools, the beginning of agriculture, the domestication of animals, the discovery of means of navigation, all these things increased the surplus at divers times and in divers places. How tremendous was the increase in social surplus gained by the combination of invention and voluntary imitation in the early periods of man's progress is indicated by a comparison of the differences between paleolithic and neolithic culture. From the earlier period rough stone implements of the chase, arrow points and what may have been spear points, but no hatchets, are found. Plentiful indication of cave-life, but, in general, no evidence of cultivation, of pottery or use of fire has been unearthed. Domesticated animals were probably non-existent. Social life was doubtless extremely simple.

Contrast the neolithic culture. When that stage first was reached

man had added agriculture to hunting, used hatchets and smooth stone implements, made pottery and baskets, erected houses, controlled fire, had domesticated sheep and cattle, had begun spinning and weaving, lived in stable villages and had a comparatively complex social life. Life was infinitely more worth living in the neolithic period. Compared with the ages that passed before the anatomical and mental characteristics peculiar to man appeared, this increase in well-being—in surplus energy—between the paleolithic and neolithic periods took place with tremendous rapidity. The actual time must be reckoned in tens, perhaps hundreds, of centuries, but, in comparison with the period that had been required for the production of voluntary imitation by biological processes, the interval between the paleolithic and neolithic periods was but a day. Voluntary imitation and invention had increased the rate of progress many-fold.

To review the successive gains through invention, discovery and imitation during the historic period would not strengthen the argument. In these latter days, we know, the power of the western world has far outstripped even the greatest population increase the planet has ever seen and at the same time has raised the plane of living far above the average of even a century ago. We may turn, therefore, to the inferences of sociological importance which may be drawn from the foregoing facts. Not merely do they show, as has been indicated, that the appearance of voluntary imitation marks the beginning of distinctly human history, but they also provide a definite reason why biological deterioration is not greatly to be feared at present and why the sociologist who bases his explanation of society more upon psychology than biology, is right. For, if it is admitted that the time required for the development of man's somatic surplus through the operation of biological processes upon his structural and mental characteristics was indefinitely longer than the period required for creation of all the extra-somatic surplus accumulated since voluntary imitation appeared, then the conclusion is apparently inevitable that, unless for some reason the biological processes that make for degeneration are much more rapid in their action than were the evolutionary processes that produced the ability to imitate voluntarily, human society is able to increase its total surplus even if somatic-surplus remains constant or even declines to some extent. To put it briefly, extra-somatic increase will more than offset a threatened somatic deficit unless the powers of invention and voluntary imitation are impaired. Somewhat differently stated, up to the limit where biological processes seriously affect them, invention and voluntary imitation will increase the sum total of social surplus faster than biological processes will impair that surplus. That this limit is likely to be reached quickly is absurd. To reach it quickly we should have to breed from the most inferior stocks alone. The burden

RISING PRICES AND THE PUBLIC

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THE increasing cost of living, or more properly rising prices, has been the subject of much recent discussion. The *causes* have been explained and reexplained; everybody knows about increased gold production, also about the trusts, the tariff, labor unions, etc., in their joint and several relations to the subject. But the *evils*, especially in their broad social relations, have been less definitely analyzed and stated. It is true that the ordinary consumer has paid more money month by month to the grocer, the landlord and others, and that he is complaining rather vigorously about it. Neverthless, for the most part he has imagined and has been taught to believe that the higher prices have meant public prosperity—*i. e.*, larger profits and more business.

Rising prices usually do mean more profits, but not necessarily more real business. The profits usually go to the grocer, the landlord and others, while the ordinary consumer pays them and is so much the poorer. Unluckily the losses and gains, both unwarranted and unearned, have not stopped simply with making the consumers poorer and the dealers richer. They have not been individual matters. The broad effects have permeated our entire social structure, operating through devious ways, working mischief upon the public.

The evils complained of are not due to high, but to rising prices. Either high or low prices in themselves signify nothing, if the incomes are adjusted accordingly. If the prices are simply high, not rising, then wages, salaries and other money incomes will be correspondingly high; all exchanges will simply be based upon a high level. Likewise, if prices are low throughout, not falling, then again wages and other money incomes will be correspondingly low and exchanges will be carried on at a low level. It is the shifting from low to high, or from high to low, that produces mischief. Various mal-adjustments in economic relations follow. All prices and values do not change at the same rate. The normal forces of supply and demand are upset. Some incomes are unduly diminished while others are correspondingly inflated. There are undue losses and undue gains; both are unearned and both are detrimental to the public welfare.

In 1910 general prices in the United States were 47 per cent.

higher than the low level in 1897. This is according to the figures of the United States Bureau of Labor. According to Bradstreets's the increase was 52 per cent. For our present purposes let us take roughly 50 per cent. Now observe the increase in the different classes of commodities: farm products advanced 110 per cent.; lumber and building materials 69 per cent.; food 54 per cent.; metals and implements 48 per cent.; clothing, fuel and lighting 35 per cent.; drugs and chemicals 33 per cent.; house furnishings 24 per cent.; miscellaneous items 45 per cent.[1]

We should note that the articles entering into the food and shelter of the ordinary consumer have advanced most, also that these items, *i. e.,* food and shelter, require about two thirds of the ordinary family expenditures—among the working classes as much as three fourths. Therefore, allowing for this fact, our estimate of 50 per cent. is clearly a conservative statement of the higher prices paid by the consumer now compared with 1897.

Our proposition is that as a result of this increase some classes of incomes have been unduly diminished and others correspondingly inflated, all to the detriment of the public. The following points should make this proposition clear.

1. Wages have lagged behind in the upward movement of exchange values and have brought consequent losses to the working classes. Money wages have advanced only about 40 per cent. compared with 50 per cent. in prices. Consequently, while the ordinary laborer receives now more dollars than in 1897, he receives considerably less purchasing power, less comforts for himself and his family, less real income.

But, why this loss? Merely because changing conditions in supply and demand reveal themselves more readily in prices than in wages. In a shifting exchange level, unless special forces intervene, wages move behind prices, advancing and likewise receding more slowly. Consequently, in an upward swing the wage-earning classes lose in real income, while in a downward swing they gain correspondingly. The explanation is that wages are controlled more by custom and social standards than are prices. When real conditions of supply and demand change, prices usually respond readily enough, still not without the retarding influence of custom. But with wages, custom is a heavy break upon change, allowing proper readjustment only after a considerable period.

The writer believes that under normal conditions of exchange real wages should have advanced in recent years. Disregard price: look at

[1] These calculations are based upon the index numbers of prices published in the Bulletin of the United States Bureau of Labor, March, 1911.

the improvements in all lines of industry, and at the actual increase in the production of commodities! Is there any doubt of increased productivity? If not, then under normal economic law, part of the increase should have gone as an addition to the real wages of labor. If this assumption is correct, the working classes should have gained in comfort and well-being, while as a matter of fact they have lost. Do you wonder at the discontent and unrest in labor circles?

2. While prices have advanced faster than wages, all prices have not moved up at the same rate. As stated in another connection, farm products, building materials and food have led in the upward movement. Other things have advanced less rapidly, some have remained practically stationary, and a few have in fact declined. Not all industries then have benefited alike from the shifting exchange level; some have not gained at all, and a few have lost.

However—and here is the important point—all laborers, whatever the industry in which they are employed, have been affected alike by the higher prices—all pay 50 per cent. more for food and rent than in 1897. Consequently, there is a pressure for increased wages in all industries, whether they have gained from the changing prices or not. Where they have gained, the desired increases may be granted readily enough, to avoid interruption of business. But where they have not gained, higher wages mean diminished profits or even losses. It is particularly in these industries where we find serious labor difficulties. Both employers and employees have lost or are threatened a loss in income. Neither side understands the position of the other and is unduly embittered as a consequence. The shifting price standards have simply deprived these industries of their former relative prosperity, and until normal readjustment takes place, the losses can not be avoided. The question is who shall bear them—employer or employee?

Fundamentally, this is perhaps the trouble in the many threatened railway strikes. Costs of railway operation have steadily advanced, while rates and fares have remained practically stationary. While this point can not be definitely determined, it seems certain that the railroads have not shared in such undue gains as have fallen to other industries through the shifting of prices. Yet they face the same pressure for higher wages; the demands are supported not only by powerful labor organizations, but by the more powerful public opinion. Until proper readjustment takes place, we must expect discontent and mischievous disputes.

Likewise this was probably the real trouble in the recent Lawrence, Massachusetts, strike. The textile mills, especially those of New Eng-

land, have apparently not shared in the unearned profits which rising prices have brought to other industries. From the workingmen's standpoint, the need for advances in wages is obvious enough. But from the employers' standpoint such advances will probably mean marked reduction in profits.

The public press has pointed to the large profits of the mills and to the fact that the stock of some of the companies is selling at ten times the par value. But these facts signify little; profits were large fifteen years ago and the value of the stock has been high accordingly. The point is, the mills have not made such additional gains in recent years as have other industries; they have been pressed by the increasing cost of production; and have relatively fallen behind in prosperity. Advances in wages will probably mean cut profits and consequently lower stock values. The writer is not defending the mill owners nor yet the operatives; he is merely pointing out a serious mal-adjustment, for which neither side is fundamentally responsible, but from which both are suffering.

3. As in the case of prices, so the wages of different classes of workmen have not advanced proportionally. Those affected pretty directly by the changed conditions of supply and demand advanced first, and those affected remotely, last. Then, if we distinguish broadly between wages and salaries, we find that the latter particularly have responded but little to the shifting exchange level.

Salaries even more than wages are controlled by custom and rigid social standards. Moreover, when they change they do so by jumps, not gradually, as wages. Thus the salary of a clerk is $800 a year, or $1,000, $1,200 or $1,500; an intermediate sum is unlikely; the passage from one to the other is difficult and is painfully resisted by the employer.

So, while wages have advanced gradually about 40 per cent.—not enough to counterbalance the rise in prices—salaries have remained almost unchanged. Again, however, conditions have varied a great deal between different classes; in few cases there have been large advances, in others moderate ones, but in the majority practically none at all. Unfortunately we lack definite statistical data as to salary standards. But, if we can rely upon observation by students of social affairs, we are warranted in holding to the general conclusion stated.

Salaries, then, perhaps more than any other class of incomes have lost through rising prices. In fact, only recently have they clearly begun to move upward. Eventually when a final high level of exchange has been reached, especially if a downward swing sets in, equitable adjustments will undoubtedly be reestablished, or gradually persons

of the needed ability will not enter the various important positions. In the meanwhile, however, the masses of salaried men, all more or less especially trained experts, can not escape the unwarranted losses. They can not leave their employment for lack of training to enter another. They have to submit to losses that are unearned, when for the most part they have deserved better of the public.

4. Persons and institutions with their capital invested in loans have found themselves gradually worse off as prices have advanced. This proposition is particularly true of long-time loans, made either before or early in the upward swing of prices. Obviously both principal and interest were fixed once for all in the loan contract. Consequently, as prices have gone up, the lender received less and less purchasing power in the form of interest, and at maturity of the loan he had also the principal returned to him in depreciated dollars. Prices having advanced on the average about three per cent. a year, he should properly have received also three per cent. a year additional interest money, and he should get back now, not the number of dollars lent, but 50 per cent. more, to offset the decline in the purchasing power of the dollar.

Specifically, if in 1897 a person lent $1,000 for fifteen years at four per cent. interest, he should have received $41.20 interest for the first year, $42.45 the second, $43.72 the third, and so an increase of about three per cent. a year through the period; likewise now, in getting back the principal, he should receive not $1,000, but $1.500. Obviously he has lost, and the borrower has made the corresponding gain. The point is, loss and gain were unforeseen and were not contemplated in the loan contract.

We have here a large class of losers, including owners of government, municipal, railway and other bonds, mortgage notes, fixed annuities, and similar forms of investments. Among persons, the class includes widows and orphans, people with savings for old age, professional men seeking safe places for their surplus income, and business men retired from active enterprise. Among institutions, there are endowed hospitals, charitable organizations, colleges and universities. In general, the class includes only cautious investors, who, so far as possible, seek to eliminate risk from their incomes. Their caution has been rewarded by losses. A virtue which is not too plentiful among investing classes has received rather discouraging setbacks.

For loans made in recent years, especially for short time periods, there has been some compensation for the loss of purchasing power. Since 1900 interest rates have averaged from one to two per cent. higher than normal. This extra rate has in part, but not altogether, offset the average annual rise in prices. The interest rate is now five

or six per cent. on safe loans, compared with about four per cent. fifteen years ago. On $1,000 the lender now receives $50 or $60 interest, compared with $40 fifteen years ago. The higher interest rate has resulted as part adjustment for the advancing prices or the decrease in the value of money. But again, just as in the case of wages, the adjustment has not gone far enough, so that there has been a net loss to the lender.

In general, as a summary of the points that have been made, wage earners, salaried employees and cautious investors have lost, while with few exceptions owners of industry and the more speculative investors have gained. The first class includes all contractual incomes, like wages, salaries and interest, which are fixed by agreement; while the second class includes principally non-contractual incomes, like dividends on stocks, profits on real estate, factories, stores of goods, etc.—incomes not fixed by agreement, but depending upon the success of the business.

Some one remarks that the losses and gains have no particular social significance; some classes merely have lost while others have gained in the scramble for income. The answer is, in part, that whenever undue losses are brought upon large classes in society, resulting in hardships and discontent, the evils communicate themselves even to the classes not so directly affected. No class lives unto itself; discontent in one will work through the whole group. However, there are also evils which are distinctly social, affecting society as such, distinct from individual classes. These evils may be outlined briefly as follows:

1. The advancing prices have introduced an extraordinary risk element into business. Undue gains have been made by some classes and undue losses by others. Gains and losses have been fortuitous; they have not resulted from mere careful or careless management; they could not be definitely foreseen, and therefore planned for or avoided. Who can tell whether prices in general will rise next year? Or the price of a particular commodity? Or wages? Or salaries? For the individual business, or person, is not a particular advance wholly an accidental matter? If with one class rising prices mean greater profits, then with another class do they not mean greater costs, which, too, are uncertain?

So far as possible, business men and people in general seek to eliminate risk from their daily relations, and they have invented insurance for this purpose. But you can not insure against rising prices, for they do not move by any definitely known law of averages. Economics can tell you why prices change, but it has not the data upon which to predict with reasonable accuracy any particular change.

Here is a risk which the business man can not escape; neither can any one else; it affects us all, and, for the most part, in an evil manner.

2. The rising prices have fostered speculation in all lines of industry and investment. Large profits have been made in recent years only by those who have taken large risks, often foolhardy ones. Cautious investors—inelegantly but clearly expressed—have been stung, while the owners of corporation stock, real estate and other speculative properties have made in many cases scandalous profits. Consequently, more and more people have turned to the riskier investments. The additional demand for them then forced their prices still higher, which in turn furnished an incentive for further speculation. Thus in many instances stocks have climbed to heights which, relative to other values, simply can not be permanently maintained. Likewise, in nearly every city of importance in the United States real estate values, particularly land, have reached such ridiculous figures compared with other prices that they simply must collapse (beholding their own monstrosity).

This means a financial panic. Credit operations in recent years have been based too largely upon uncertain and inflated money values. Some time in the reasonably near future, during a period of rather general liquidation, the paper profits of our speculative classes will show what they really are—phantoms which dissolve into nothingness at the touch of business reality.

The panic of 1907 was perhaps principally due to the speculation of the previous period of rising prices. However, except for a temporary halt after the panic, the movement upward has continued unabated. Moreover, it probably will continue many years to come; at least the fundamental cause of the movement—excessive gold production—gives no promise of lessening its operation for a long time. In the meanwhile, before final adjustments are made, before a final high level of prices is reached, or before a downward swing is started, the writer fears that we are doomed to several panics, probably severe ones, bringing disorganization of values, collapse of business, unemployment and general hard times.

Apart from panics, look at the social waste of speculation! For example, the ordinary dabbler on the stock market has no real interest in the corporation whose stocks and bonds he is buying, and he does not create any substantial values. Nor does he buy because he knows that the stock is selling for less than its intrinsic worth. He has a tip or a "hunch" that the price will go up, and he takes a chance at easy money. But win or lose, he neglects any sound business for which he is trained, and so wastes his time for the public.

Likewise, the multitudes of real estate dealers the country over are not *bona-fide* real estate men, studying the needs of their community,

improving run-down properties, planning and laying out new residence sections where demand is likely to go, and in other ways anticipating the needs of the people. On the contrary, they are merely guessing at changing values, holding property, not to improve it, not to supply any need which they have foreseen or created, but merely hoping for higher prices and handsome profits. Undoubtedly many persons have reaped and many others will reap large rewards by this process; also many have lost and many others will lose by it. But this is the important point: all are neglecting any real industry, so that for the public at large there is a scandalous waste of energy, which should be turned to useful purposes.

3. Finally, rising prices have fostered extravagance. Some one has facetiously remarked that we are suffering less from the high cost of living than from the cost of high living. This is in a large measure true. The point here is that the high living has resulted in a considerable degree from the increasing cost of living.

The ordinary consumer feels clearly enough the greater cost of practically everything he buys compared with fifteen years ago; but he also receives a greater money income, whether in the form of profits, interest, wages or even salaries. On the one hand, he realizes perfectly that money is not worth so much as in 1897, for prices are higher; at the same time he has an ingrained feeling that the value of money never changes. He receives now more actual dollars and he feels almost correspondingly better off and spends according to more lavish standards. Further, after paying for food, rent and other necessaries, although the sums are large, he has now left a larger surplus than in 1897 to be used for other things. It is particularly the value of this surplus that he does not understand; it is only *apparently* larger, actually it is smaller. And it is particularly the spending of this chimerical sum that has led to extravagance.

We have to do here with a peculiar contradiction in feeling. In one sense people are perfectly aware that the value of the dollar has decreased, for prices are higher; but in another sense they have the ingrained notion that the value of the dollar is a fixed, absolute, unchanging thing. We may call this contradiction, the paradox of the sense of value. This paradox is common even among persons trained in the science of money. It has led many classes of people to adopt unwarranted scales of expenditure, especially in reference to amusements and various forms of display.

For an illustration, suppose that since 1897 prices have increased 50 per cent. and wages 40 per cent. Then a working man who received $600 a year in 1897 and spent $400 for food and rent, receives now $840, and spends $600 for food and rent. Naturally he feels better

off than in 1897: he receives now $2.80 a day instead of $2.00, and he has a surplus of $240 a year above food and rent instead of $200 as in 1897. Likewise a clerk or mechanic who in 1897 received $900 and spent $600 for food and rent, receives now $1,260 and spends $900 for these necessaries. He receives now $4.20 instead of $3.00 a day and has a surplus of $360 instead of $300. In spite of the higher prices this additional money makes him feel better off than before; consequently he has enlarged his ways of living according to his feelings, not according to his real income.

Merely to offset the price changes the workingman of our illustration, to be as well off as in 1897, should receive $3.00 a day instead of $2.80 which he actually gets, and he should have a surplus of $300 over necessaries instead of his actual $240. Likewise our clerk and mechanic should get $4.50 a day instead of his $4.20, and should have a surplus of $450 instead of his actual $360. In fact, both laborer and clerk have been losers and they have erroneously felt themselves gainers in income.

The same paradox appears with classes whose incomes have advanced proportionately with prices or have advanced faster. Everybody has the feeling of having more income than he actually has. The middle-class man who formerly saved $1,000 a year should now according to the same standards save $1,500 to offset the 50 per cent. increase in prices. Everybody to save as before should set aside annually 50 per cent. more dollars. Among social classes throughout, how large a proportion of people are doing this? If not, people are not saving as they think they are. The man who formerly carried $10,000 life insurance for the protection of his family, should now carry $15,000, merely to have his family protected as before. Any one who has not followed this ratio of increase is not protecting his family as he supposes. Further, merely not to be poorer a person with a capital of $100,000 should now have $150,000. Any one whose capital investment has augmented less than this ratio has obviously lost in real financial standing.

All along the line the diminishing dollar has played tricks on our sense of values, making us feel more prosperous than we are. As a consequence too many of the working classes have regularly indulged in Coney Island or in its miniature counterpart, in picture shows, swell clothes, etc. Too many of the middle classes have attempted automobiles, expensive summer vacations and trips abroad. Of the extravagance of the rich, there is no need to speak; it has been so glaring and senseless. Luxurious living is excellent if you can afford it. But insidiously we have been led into extravagances that we can not afford. Too many of us have been living on capital, erroneously thinking it income.

To be sure, the growth of extravagance can easily be exaggerated. It must be admitted that the rising prices have also the effect of leading to certain economies. Many families have undoubtedly made proper adjustments in their expenses and savings all the time as prices have been moving upward. Also, even in the ordinary household, the resentment against constantly climbing charges has unquestionably resulted in many more frugal uses and cheaper food substitutions. For example, now with butter at 40 cents a pound and eggs at 35 cents a dozen, the various cake and other pastry recipes call for little more than half of these ingredients compared with fifteen years ago, when they were bought for less than half their present prices. Now, when desirable cuts of meat cost from 20 to 30 cents or more a pound, people are turning more and more to cereal and vegetable foods—probably with physiological as well as financial advantage. Other similar savings might easily be cited.

But, while such economies have undoubtedly been made, often even painful ones, the paradox which we have been discussing has not been necessarily avoided. Too often these economies are counterbalanced by extravagances in other directions. What is saved on butter and eggs and meat is more than offset by moving pictures, nifty clothes, an automobile, or what not. Probably very few people have completely escaped the lure of living higher than their real income affords. How impossible, or at least how hard, it is even for the most prudent to know, and all the time to *live* as if knowing, that the dollar is not always a dollar!

Speculation and extravagance are closely related manias. Their worst feature is that they fasten themselves rather firmly upon the people. We can study their effects and their causes, but we do not know very well how to remove them. They will abide with us probably a long time after prices have reached their high point or have begun to swing downward, or after other causes have subsided. Customs and social standards change slowly.

In conclusion, the writer would admit that many causes have probably contributed to the growth of speculation and extravagance in recent years. He does not believe that the rising prices have been the sole cause. But he is convinced that in the ways pointed out they have been a powerful factor in fostering these social evils.

As a practical matter for the public at large, everything possible should be done to prevent any considerable change in the price level—either upward or downward. So far as possible, the dollar should always be a dollar; its value should be a fixed, absolute, unchanging thing. If not, the evils are bound to appear as they have been stated.

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THE FUNCTION OF THE AMERICAN COLLEGE

By Professor A. K. ROGERS
UNIVERSITY OF MISSOURI

ALONG with the movement toward vocationalism in the lower schools, there is at the present time apparent an equally powerful and not wholly unrelated trend in the higher toward intellectual specialization. Any one who is acquainted with the situation knows that in so far as the college and university teacher has to-day any distinct notion at all of what he is about, it is likely to be in the majority of cases in terms of an exaltation of scientific scholarship. The business which he conceives he is there to forward is to produce thinkers and investigators of the specialized and technical sort that he is familiar with among his colleagues and in his scientific associations. And the commonest justification of this is apt to be in the form of a claim that the task of the schools is to produce leaders. In consequence the teacher gets into a habit of considerable asperity toward the average member of his classes in whom he sees no special promise of distinction. His dealing with them becomes perfunctory, and all his enthusiasm he reserves for the few who can be expected to go farther along the paths of academic glory. The special ideal of the university is apt to overshadow the entire scheme of higher education.

One result of this tendency is the anomalous position which the college is at the present day coming to occupy in the American educational scheme. To one who is not content to see an institution simply in existence, and doing work which has something to be said in its favor, but who wants to adjust it to a principle, it is growing a very puzzling matter to state with any approach to precision the function of this typically American contribution to the forms of educational expression. The original function of the college was professional preparation, which at the same time came pretty close to a training for social leadership as well, since the professions to which it led, including in particular the profession of divinity, were looked to more consciously than at the present day to provide the material for leadership in ideas. But if one were to try to justify theoretically the college now on the same ground, two facts at least would need to be recognized. In the first place the college does not actually at present, except in the form of a pious aspiration, base itself upon intellectual distinction, or aim at developing peculiar capacities for special kinds of intellectual service. And we can the more readily admit this, inasmuch as in the university we have a new type of institution which does have just this aim. Accordingly,

since the discovery and promoting of peculiar intellectual excellence is perhaps the most obvious statement of the end of higher education, we find a strong disposition of late among those who care for the theory of education, and like logical neatness, to look forward to the day when the college as an institution shall have been shorn of its present importance. The tendency is rather strongly in favor of cutting off the college proper at both ends—assigning the last two years to the university as a preparation for technical professional work, and either adding the first two to the high school, or leaving it a torso which would seem bound to approximate to the type of the academy.

A defense of the college as a peculiar institution will need to recognize first, I think, two sets of distinctions. One is the distinction between professional or scientific efficiency in specialized tasks, and an intellectual leadership in the sense in which this affects directly the general life and ideals of the nation. Now that the university is the instrument for developing the first or specialized intellectual capacity, of course goes without saying. But that this is identical with the second sort of eminence and leadership, pertinent to the political problems of democracy, is not in the least self-evident. At present I simply call attention to the distinction, and to the fact that if we think fit to introduce at all the social need into the argument for education, we should not identify this with the sort of scientific leadership which the university does confessedly aim to develop.

But now my argument for the college would be, that while the purpose which gives it a right to continued existence alongside the university is distinctly its social rather than its professional, or, in the narrow sense, scholarship, value, it is not primarily social *leadership* that it should aim directly to provide for. The second distinction is that between the comparatively small body of notably able men who will always have to direct the course of society and interpret for it its ideals, and the larger body of enlightened opinion which is needed to direct this in turn and keep it from substituting a caste ideal for the people's will. And it is in the creation of this last that I should find the special purpose of the college to lie.

That the tendency of the university ideal to emphasize too exclusively the importance of special ability constitutes a possible social danger is, I believe, coming to be felt. An emphasis on ability turns almost inevitably under modern educational conditions in the direction of specialized ability. The exaltation of the university ideal is therefore coming to mean a sacrifice of breadth and perspective to the demands of technical proficiency. This may mean, if it goes farther, that our most highly educated classes no longer will possess the qualifications that are needed for sound human political judgment in a democracy. A catholicity of interest and sympathy is required here rather than

scientific habits of mind applied to some narrow field; without it, there is not the slightest guarantee that the trained man will be a better citizen, though he may be a better physician or lawyer or engineer, than the comparatively uneducated artisan. Indeed the artisan, because of his wider human contact, may easily have the advantage. That the specialist is in constant danger, through over-estimating the sufficiency of the scientific intelligence, of losing his sense of democratic proportion and so becoming a member of a narrow caste, is shown in the actual tendency in academic circles. On the whole, the university reveals a tone of aristocracy which is constantly passing over into snobbishness. It inclines to the principle of the closed shop, where a small group of men with peculiar interests look down with more or less imperfectly concealed disdain upon the uninitiated. If one is convinced that in this direction social salvation lies, very well. But if he still inclines to the older ideals of democracy, it will seem to him a risk. And the nearest salvation lies in the creation of a more massive body of enlightened good judgment, which shall bridge the chasm between ignorance and special ability, and obviate the excuse which the pretentious claims of the few profess to find in the incapacity of the masses.

Now in the American college we have an institution which seems admirably fitted to perform just this service if it sets about it in the right way. So regarded, its function would be not to cater to the specially gifted class, but to provide a means by which the great mass of ordinarily intelligent men and women can, if they have the will, absorb a measure of disinterested culture, and so broaden their vision of men and things that, leading the lives of ordinary citizens, they may furnish a saner, less hide-bound, more dependable quality of citizenship, such as is needed to temper the ambitions and the self-sufficiency of the powerful and able few, and to afford a medium through which more humane and gracious political manners may leaven the majority. It seems verv questionable whether the extension of the high school could accomplish just this task, certainly as the high school exists to-day. For the earlier work of the high school necessarily presupposes a lack of maturity which determines its methods as not the same that the college requires; and constituted as the pedagogue is and probably always will be, it is too much to expect that a teacher will be able to adapt himself successfully to two quite different tasks.

I look, therefore, to see the college more and more, if it recognizes its responsibility to democracy, make its main end not scholarship in the technical sense, but breadth, poise, vision. Furthermore, it must aim to extend its opportunities to just as many as possible, instead of serving as a selective agency to sift out those of special promise in things of the mind. I do not mean by this that to every one alike a college course is beneficial. Doubtless there are many now in college who would

be wiser to turn to some more immediately practical and active work. But the situation which makes such a judgment common among college instructors is not, I am persuaded, just what it is frequently interpreted to be; it is not, that is, proof of a hard and fast demarkation between the intellectually unfit and the elect, based on distinctions of natural equipment. There are at least two other reasons for the sort of difference between students which makes it so difficult oftentimes to adjust teaching to the material it has to work upon. The first is the lack of preparation in the foundations of intellectual culture which the student brings to the college—particularly in the power of good observation, accurate thinking and clear English expression. A large share of the difficulties of the college teacher consists in overcoming the handicap with which the student starts. But theoretically this would not exist if our lower schools were what they should be. Not, of course, that it is equally easy to teach even these to all minds. But it is possible to do it for the great majority. And for the lower schools, at any rate, to fall back on the plea that they are there simply to provide the materials of knowledge, while disclaiming responsibility for the mass of those who need special encouragement and attention, is to confess the bankruptcy of our educational system.

The second great drawback to a proper level of attainment in the mass of college students is the lack of interest and ambition. But this again is a largely improvable situation. The simplest way to meet it would be undoubtedly to devise plans for the quick elimination of students who show that they have no real desire for a college training. In this I can see no injustice; it only would be well before putting it in operation, that educators should search their own hearts to make sure to what extent the fault lies in themselves. The temptation is, again, to take too readily the stand that the business of the teacher is merely to set forth his educational wares, and leave it to the student to make what use of them he will. And if our aim were merely to develop special ability, as indeed it is in the university proper, there would be nothing to be said against this. If, however, we take the stand that education is not a matter merely for selected individuals, but has a duty to perform in leavening the mass, it becomes an important point of the teacher's duty to develop interest, as well as minister to it when it is already there. For a persistent intellectual interest is not a natural taste, but an artificial one. Natural interests furnish its conditions. But these are transient for the most part and easily discouraged; to turn them into permanent habits of mind needs all the technical skill and pedagogical enthusiasm that can be brought to bear. But when our school methods, lower and higher, are revised to this end, then a rigorous process of weeding out such portions of the student body as show no genuine purpose and effort, but treat instead their studies as incidental

to the ends of athletics, social functions or the pleasures of inertia, is not only justifiable but necessary for any worthy standard of educational work, and if acted on intelligently would go far toward getting rid of the greatest difficulties in the proper working of the college.

But with these drawbacks discounted, I do not believe there need be any great problem arising from the merely average, the naturally less gifted student, who comes to his work well prepared in fundamentals, and with enough of interest to lead him to exert his best powers. And it is to this class in particular that the college, if it is to have any reason for existing alongside the university, should, I believe, professedly aim to adjust itself, instead, as now, of accepting the situation as one that is forced upon it, while its heart is in the university ideal of making professional scholars and investigators. And the reason is, again, that the exceptional man in a democracy loses a great share of his social value unless there is a large public to which he can appeal, through reasoned judgment rather than emotional prepossessions—a public possessed of a maturer outlook than it is possible for the high school to insure. This is not to give countenance to the superstition that no one can be a sound philosopher and a good citizen without a college degree. And I am intending, too, to exclude a more debatable aspect of the matter which confronts us under present academic conditions. It undoubtedly is true that many men now in our colleges might well be advised that they are out of place; not, however, because such a training might not enhance for them the value of life and enlarge their own value as citizens, but because if they persist they are likely, owing to the common aristocratic conception of a college course which they share, simply to look upon it as a means of escape from the life work for which they are really fitted, in order to enter a more respectable line. It is this tendency to a resulting maladjustment, perhaps, which teachers have in mind when they deplore so frequently the ambition of certain students for a college career. But if, instead, they are setting up to say, on any large scale, that a man's mind is unimprovable, and that he is a fool to try to make of himself anything but the slow and stupid animal he is by nature, one can only attribute such a judgment to that other product of nature—an intellectual intolerance and superciliousness which should be educated out of the teacher, of all men, before he is fit for his job.

If this aim be accepted for the college, certain modifications of academic tradition might conceivably follow. It would suggest some change of attitude in the matter of conditions of entrance. The purpose would then be to encourage as many as possible to utilize the advantages which the college offers, whereas at present the chief concern seems to be to keep out the unworthy. Of course the justification for such entering tests, which are all the time becoming more rigid, is the

standard which the college is called upon to maintain. The motive is a good one, though one may suspect that intermixed with it one less defensible also plays a part. Interpreted by the professorial mind, it too often takes the form of an illiberal prejudice against admitting to the benefits of learning any one who has not gone through with a particular sort of officially recognized initiation, and thus complied with all the regulations of the guild. The need for some sifting out process is, however, very real, and it has seemed the easiest way to erect a strongly picketed fence, and take great pains to see that no objectionable person gets inside. This has advantages, but at least it is unfortunate that it seems to place the emphasis on exclusion rather than on the offering of opportunity—a result which will show itself in pretty nearly any college faculty, where a question of the stricter interpretation of entrance conditions can be counted on to arouse more enthusiasm than is ever called forth by the case of the ambitious and possibly quite capable student who can not meet the academic tests.

It is scarcely to be expected, perhaps, that the college will turn back from a policy so apparently settled. But it may at least be noted that there is an alternative program. The only condition that is really essential for permitting a student to take a given piece of work, is his ability to do it with profit, and without detriment to the proper workings of class-room efficiency. And to substitute for this the record of past attainment, often merely nominal, is not only to erect a fetich which may become obstructive, but it is largely to fail of the end in view; for every teacher knows that the possession of "credits" is almost no indication that a boy is ready to go on with a new task. If instead of making a test which precedes actual trial, the college were to make this trial itself the test, were to let every one have his chance who wished to take it, and then expeditiously and firmly exclude him so soon as it became apparent that he was a misfit, not waiting until the end of the year or of a term, but acting the moment there was no reasonable question, not only might the real end be attained much better than it now is attained, but it would be secured without danger of turning the college into a thing of mechanism and red tape. and without restricting the advantages of education beyond absolute necessity. The reason why this would not work can only be in terms of the instructor himself. If he will not take the responsibility of using his judgment, but will allow things to drag along without remedy, he will soon be in trouble. But whereas there are institutions doubtless in which it is advisable to discount as much as possible the defects of the human factor by machinery, education is emphatically not one of these; and the tendency to make it such is one of its greatest present dangers. As a matter of fact there seems nothing so far beyond the powers of the average man who is competent enough to deserve a job on a college

faculty, in the supposition that he should have enough judgment to sift out those who are not likely to profit by his work, and consequently should have the power to exclude them from his classes. If such a demand upon him were to compel a more direct personal relationship with his students, that would not be an unmixed evil. As a matter of fact, the trouble does not lie so much in the inherent difficulty of the task as in its lack of harmony with academic precedent. Our system rather presupposes that since past attainment is the claim to recognition, when once a man has got inside he has a prescriptive title to remain, unless some extraordinary reason forces his expulsion.

It might very well be that such a system would modify to an extent also the place of the degree in education. But the sacredness of the degree is in any case open to question. It is now a title to intellectual respectability of the peculiarly unfortunate sort which combines with a claim to superiority, denied to its non-possessor, a thinly veiled recognition by the informed that its real content is merely nominal, and that it can be counted on to stand for little more than the fact that its holder has passed four years at a given locality, with enough attention to his books in the intervals of more important occupations to prevent naturally lenient instructors from condemning him as beyond question unfit. The justification of the degree is solely the aid it renders in the desperate enterprise of inducing in the general mind a sense that scholarship has its points; it marks therefore a failure of more fundamental motives, and its claims can not be pressed too hard until other efforts have been exhausted. Probably it will have to be retained along with other relics of medievalism, though there is no reason why at the same time there should not exist a large increase of students without full technical preparation, or the ability to pursue their academic work at length, who will cease to be regarded as so much dead weight, and be recognized as having human if not scholastic claims. And at least if the degree is to hold its place, this apparently can only be on condition of the already strong tendency to make its meaning exceedingly elastic. The endeavor to keep the degree true to what traditionally has constituted the education of a gentleman, disguised under the name of liberal, is really the attempt to keep up the fiction of a learned class marked off by formal insignia, under the pretence that there is only one royal road to culture.

And if now we turn in conclusion to the second aspect of the social purpose of education—the equipping of the narrower class of intellectual leaders on whom will always depend the initiation and the steering of social progress, I venture to think that this is a much less important problem than the former one, for the simple reason that here the root of the matter lies in large measure beyond the province of educational machinery in the lap of nature. The exceptional man is pretty

apt to look out for himself. He will thrive probably in spite of our attempts to educate him quite as much as because of them. The most that society can do is to have plenty of opportunities ready to his hand, and see to it that unnecessary and artificial restrictions do not prevent his free expansion. Naturally the college will receive all alike, the exceptional and the mediocre; and one part, though a secondary part, of its function will doubtless be to bring to light the man of brilliant parts. But its machinery will be wasted if it sets itself to this as its main task. To what extent the university with its specialized training is likely to cooperate to the same end, it is not easy to say. Certainly it has not done a great deal in the past, and its specialized and academic character is against it. There is a well-founded distrust of the capacity of the academic mind to set the standards of society. Even its good points are against it. There is such a thing as being too reasonable, if reliance on reason makes us, as it tends to do, over-critical and afraid of action such as anticipates grounded theory. The specialized university can produce the economist and the legal expert; beyond this it is not so clear. What distinguishes the real leader from the expert is precisely that broad outlook and human sympathy which constitutes culture. And specialized training, uncorrected, tends also to obscure that feeling of the need for submitting scientific reasoning in state matters to the test of popular agreement, which alone is consistent with the democratic ideal. Upon the college, then—when nature does not ignore the school and the schoolmaster altogether—most of the task seems likely to fall. If it can devise some plan to meet the special needs of the exceptional man, that he may not be encouraged merely to keep pace with the mass, so much the better; if not, he will probably make his own opportunities. Meanwhile nothing in the attempt should jeopardize the main end of the college, or induce it to give way to that seductive tendency to exalt overmuch the claims of cleverness, which is the peculiar temptation of higher education.

REFORMING THE CALENDAR

BY OBERLIN SMITH

"YES, tempus fugit," remarked a philosophical gentleman of African descent, as I sat in his barber's chair remarking that my time was limited, "but," he went on to say, "we should not speak of time flying, for *we* fly through time." This seems logical, and new, but in whatever way we regard time we must certainly measure it; and we now measure it rather foolishly—not so foolishly, however, as by many systems in the past. Reformers of all ages have struggled with the question of how to divide three-hundred-and-sixty-five-and-about-a-quarter into any convenient groups of units. A division into months was doubtless suggested by the motions of the moon, but the twenty-nine-and-a-fraction days forming her cycle were not commensurate with the earth's yearly cycle and nothing but confusion could arise from trying to use a lunar month for practical purposes. Certain attempts in ancient days led to such inconvenient time-keeping as was shown in the old Jewish year, which varied from 353 to 385 days, the months approximating a lunar cycle and an extra one being inserted sometimes each second, and sometimes each third, year.

The ancient Egyptians used twelve 30-day months and five odd days over, with no leap-year. This brought about the pleasing result of having the calendar year begin at all possible times in the astronomical year. Thus a complete cycle, to bring summer back again so that it would occur in summer, was about 1,461 years in duration. As nobody waited to see the end of it, not many people were greatly inconvenienced. When the Julian year was established in 46 B.C. with 365 days, and an added day each four years, the seasons stayed where they belonged much better, but they naturally had gotten somewhat awry by 1582 A.D., when the present Gregorian year was established. It would seem that if Cæsar and Pope Gregory XIII. (and also the Persians, in the early middle ages) thought the calendar of enough importance to be reformed by radical changes, we, in this day of rapid reforms, should be willing to make the slight changes necessary to get rid of the illogical and troublesome system now in use.

Among the annoying inconveniences of our present calendar are the changing of the dates in each year at which the respective seasons, months and weeks begin, causing various holidays and other special days to be movable as regards the day of the week and often to be postponed to a new date, upon the day following, when they happen to

occur on Sunday. Another nuisance is the inequality in the length of the months and the random fashion in which the various lengths occur —this irregularity even requiring the memorizing of pretty little poems, such as "Thirty days hath September, etc." Still another evil is the starting a new year about one-third way through a season instead of each beginning at the same time. Still another is the ten days discrepancy between the beginning of the calendar year and the solar year, there being no good reason why they should not start together—say at the winter solstice, instead of a little after, as at present.

There is hardly room herein to fully discuss the question historically or to analyze all that is now being done to effect a reform in our curious calendar. It may, however, be interesting to get an idea of a modern view of the case by compiling a résumé of a series of articles upon calendar reform, written by various students of the subject during the past year or so.

Referring to *Science,* Vol. XXXII., p. 154, a communication from Professor Reininghaus advocates changing the present Gregorian calendar by starting the year with six months of 28 days (four whole weeks each) followed by a half-month of two weeks, then by six more such months and another half-month. This completes 364 days of the year. To them is added a non-week day, followed in leap-years by another day.

On page 306, same volume, Dr. Slocum quotes Mr. Cotsworth, of England, as recommending thirteen 28-day months, putting the extra one in midsummer and calling it "Sol." He then puts in an extra day, calling it "Christmas," and each four years inserts a "Leap-day."

On page 513 Professor Patterson quotes Sr. Hesse, of Chili, as advocating thirteen 28-day months, plus one or two necessary non-week days, suggesting that the new month shall come in winter and be called "Trecember." Professor Patterson, however, prefers to have the new month in summer and suggests "Roma" for its name. He also advocates that we number the hours of the day from 1 to 24, instead of putting in duplicate groups of twelve each, as now.

On page 556 Mr. Dabney agrees with the 13-month advocates above mentioned. He refers to possible difficulties in arranging the legal holidays, which seem to depend somewhat upon politics and public enthusiasm. He thinks that outside of the four old-fashioned ones, they had better be made to occur on Sundays so there would not be too many of them to interfere with regular weekly occupations.

On page 628, Dr. Cohen fears differences of opinion among followers of the various great religions, should some calendar reform be made universal. He proposes that we do not name the days at all, but simply number them from one to seven in each week as do now certain of the religious denominations, and as did the ancient Hebrews.

On page 757 Professor Chamberlin advocates giving plenty of time to a careful study of a possible new calendar, but suggests that the best arrangement would probably be twelve months of four weeks each and four extra weeks, one placed at the end of each of the seasons. These intercollated weeks, as we might term them, would be used for closing up accounts in business and school-work, taking short vacations, etc. The 365th day he would make New Year's Day, with a leap-day added every four years. He proposes special names for the extra weeks, as, for instance, Christmas, Easter, Julian and Gregorian.

On page 917 Dr. Hopkins criticizes Professor Chamberlin's scheme and suggests instead, the adoption of eight 4-week months and four 5-week months, the latter to be 3d, 6th, 9th and 12th of the year. To avoid any greater space than seven between Sabbath days he advocates running all weeks consecutively and having every fifth year an extra so-called leap-week. This leap-week would be omitted each forty years, save the 10th and each 20,000 years except the 10th. This, he figures, would bring everything out all right in the long run, but he doesn't suggest how many of us will live to see that it goes through properly.

In volume XXXIII., page 64, Professor Barton analyzes the Chamberlin and Reininghaus schemes and objects to starting winter as late as the first of January, and also to so-called quarter-years having an odd week appended as making it awkward for the future timing of contracts, etc., especially those which are based on monthly periods.

On page 688, the late lamented Professor Webb recommends, as a temporary matter, that the years from 1918 until 1924, inclusive, shall each consist of 52 weeks or 364 days, and that we then shall commence a system of having each fifth year a long one containing 53 weeks, or 371 days. Subsequent to the last date mentioned he would abolish the term "month" and have as units only weeks and days, numbering all the days of the year consecutively and knowing them by such numbers. The inaccuracies of thus counting consecutive weeks indefinitely onward would be corrected by omitting the long-year in year dates divisible by 50, except at different intervals about 400 years apart.

On page 690 Professor Kent regards favorably the usual four quarters and twelve months, but would, in common years, give February 30 days by robbing two of the present 31-day months, and would give February an extra day in leap-year.

On page 690 Mr. Clifford has referred to the movements for reforming the calendar in France, Holland, Switzerland, etc., which have been going on for more than twenty-five years past without exciting much attention in this country. The general consensus of opinion abroad seems to favor the simple scheme of four quarter-years each with two 30-day, and one 31-day months, with a non-week day at the end of common years, and two of them in leap-years, the second one to be at

the end of the second quarter. The year 1917 is recommended for making the change as allowing plenty of time for discussion and decision throughout the world, and as fitting in properly to start with the first day of the year coincident with the first day of the week.

On page 803 is a quotation from an article in *Nature,* by H. C. P., which relates that certain propositions for calendar reform have been unsuccessfully introduced in the English Parliament. One of these called for the simple arrangement above described by Mr. Clifford and others, while the second one calls for seasons of 28-, 28- and 35-day months. The author points out the absurdity of the second scheme, with its perplexities in arranging for monthly salaries of servants, etc.; and discourages any movement of the sort as unnecessary, and as interfering with the present continued succession of the 7-day weeks, fearing that any change could not be accepted on religious and sentimental grounds. The whole tone of his communication is perhaps a little too pessimistic to make it worthy of a serious place in an article upon reform.

On page 283 of the March, 1912, number of this magazine, Dr. Super, in an article upon "Time and Space," recommends the same simple and scientific arrangement of four 91-day seasons, etc., recommended by Clifford and others.

Referring in general to the schemes of the various authors above quoted, we certainly should not consider any of the 13-month projects, simply because thirteen is not divisible by four, the number of seasons that we have assumed desirable. Months of 28 days would be still more awkward, if some of them were rated as half-months, as suggested in one of the essays. The suggestion of four 12-week seasons, each followed by a holiday-week, would seem to be rather confusing as it would mix two different sorts of units, seasons and weeks.

The scheme for a temporary change for the next thirteen years, and then another change, making every fifth year a week longer than the others, would also be very inconvenient. We should try to make the years all as uniform with each other as possible, only varying them the one day at certain intervals as seems to be forced upon us by nature. Obviously, commercial values such as interest, rents, salaries, etc., based upon a 52-week year would not be suitable for a 53-week year. Another suggestion that we merely lengthen February and shorten some of the other months in an arbitrary and irregular way does not seem worth considering, as little real improvement would be effected.

The Dalziel Bill, which has been presented in the British Parliament having months with 28, 28 and 35 days for each season, seems utterly impracticable, especially in the matter of calculating monthly wages, rents, etc. The Pearce Bill, however, presented earlier in Parliament, with four 91-day seasons and an extra non-week day, etc., seems to be

almost ideal, and agrees, in its main features, with the proposals that have been made by various scientists in Europe for several years past, commencing perhaps with M. Flammarion and referred to later as the "Grosclaude Project," with headquarters at Geneva. It seems to have been considered favorably also by some of the Esperanto congresses.

Such simple schemes embody the only logical method of handling the subject, as the primal conditions of any calendar reform that we may hope to succeed in adopting throughout the civilized world are, first, simplicity, and, second, the least possible change from our present system. It probably will be generally conceded that if we make a change we had better retain the present division of the year into four seasons, into twelve months, and into weeks of seven days each. Of these the natural and unalterable units are the year and day. The difficulty throughout the ages has been to make one of these commensurate with the other when nature has kindly made their ratio about 365.2422.

After completing these four seasons, by whichever of the exact arrangement of months that may be considered best, we have, in any of the cases, 364 days. The remaining non-week day in common years simply fills a little gap and may be called by any appropriate name. It doubtless should be a holiday, but preferably belonging to the old year. In leap year the extra day should be put in the middle of the year, thus making each half-year alike, it being considered the final day of the first half and being a holiday. It perhaps might be called "leap day" or, preferably, something more euphonious.

A primal advantage of this general scheme is that the beginning of each year and any certain day of any year, counting numerically from the beginning, always happens the same day of the week and, furthermore, that each season always begins and ends with the same day of the week, because the 91 days are divisible by 7.

In any of these good schemes, where we keep years almost the same length, varying by only one day in leap year, we meet with the academic objection that the weeks do not run forever in an unbroken line of seven days each. This, of course, would make no trouble in social or commercial life, but it might be contrary to the religious scruples of some people as occasionally giving them an 8-day interval between two sabbaths, instead of always seven days. This could be gotten over, however, if necessary, by calling the additional day a sabbath and thus having two together once a year, and in leap year twice a year. A better plan would perhaps be to let the extra day of the year be Christmas, thus allowing only the holiest of all days to crowd certain two sabbaths a little apart. To those people who believe in the great importance of an exact sequence of 7-day weeks, which they suppose to have been maintained since the christian era, and which must always be maintained, it may be suggested that if they ever are traveling

westward their weeks are perforce lengthened to more than the standard 168 hours. Should they happen to go all the way around the world they make their weeks so long as to be obliged to throw out a whole day into the Pacific Ocean, thus giving them one 6-day week. If, on the other hand, they travel eastward, their weeks are shortened, and by the time they get home they must have endured one 8-day week. This being the case, how can they logically object to a calendar reform which would only have the same effect upon them, at certain long intervals, as would an extended eastward journey.

Whatever reform is made, one point especially should be insisted upon (one that the calendar reformers seem to have neglected) and that is to start the new year about the twenty-first of December instead of ten days later, as we now do. Thus the calendar year and the solar year would have a definite relation to each other—as they properly and logically should have. Here again an objection might be offered that when the change was made some certain two sabbaths would come too near together, or too far apart, but as this would only happen once for all (it is to be hoped for many thousand years) the difficulty would not be a serious one. Even this could be avoided, however, simply by choosing a suitable year for the grand change.

To those persons who object to the first season (winter) beginning 21 days later than it does now, it may be pointed out that we of the north temperate zone are apt to have many more cold and disagreeable days in March than we do in November and that the early part of September is but a continuation of summer. The occasional frosts which we have in June that so often "spoil the peach crop" (for the time being!) may perhaps also give a hint that summer might just as well commence a little later than it now does. To the thought that we should logically place the middle of the cold season at the solstice, when the earth receives the least sunshine, it may be replied that there is a *lag* in meteorological phenomena which is the interval between certain causes and the effects which follow. The retardation is due to a variety of physical actions, as the retention of heat in the earth, water and air, and so forth. The length of this lag is uncertain and irregular, but probably a half-season is a near enough period to allow. All of our weather is so variable that it is not feasible to attempt running it upon an exact time-table.

It should be understood that the word "season" is used herein synonymously with "quarter." The latter is of course frequently used in business matters as a division of a fiscal year. There is no reason, however, why the commercial quarter-year should not be identical with the climatological and sentimental unit.

Incidental to this calendar reform, but not necessarily a part of it, is the numbering of the hours of the day from 1 to 24 instead of by the

present absurd method, involving two sets of twelve hours each, all marked with the necessary appendages, "morning," "afternoon," "evening," "A.M.," "P.M." and so forth. All this is just as sensible as it would be to name months enough for half a year only, and then to repeat them during the last half, with some cabalistic letters attached to distinguish them from the first set. It is surely more logical and definite to commence the day at midnight and number it straight through, as we would number any other series of parts belonging to a whole. If our clocks, watches and railway time-tables were numbered in this way, it would require but a few months for everybody to become entirely conversant with the new method. The writer has long carried his watch with the hours from 13 to 24 marked in red figures below the usual black ones. Any old time-piece can be so marked and the new scheme thus automatically becomes familiar.

The improved numeration has long been in use by the big Canadian railways and by various railways in Europe. It is also used by the general public in some places on the continent, but just to what extent I am not fully informed. Only to-day the news is cabled that the 24-hour scheme has been adopted in France.

Some years ago this numeration was advocated and practised at its conventions by so scientific a body as the American Society of Civil Engineers. Thus, they habitually, upon their programs, etc., appointed afternoon meetings at 14 o'clock; dinners at 19.30 o'clock and dances at 21 o'clock, and so on. They have for a few years allowed the matter to drop, but it is to be hoped only temporarily.

In the diagram below I have tabulated the chief points of the Geneva scheme before referred to, except that I have used the German spelling "kalender" which I suggest for future use, to distinguish it from the old "calendar" previously used. It is better thus to place the 31-day months at the beginning of the season rather than at the end; firstly, because in such case there are two less of the old months to change the length of than is the case by the other plan; and, secondly, because with a 30-day month at the end of the season, the "leap day" following June and the "extra-day" following December can, if desired, be considered as part of the month preceding them, thus giving it thirty-one days. This need not affect the position of the weeks, but it might be convenient in some cases involving monthly stipends, as in paying for domestic service, etc. Thus, there never would be thirty-two days to consider as perhaps belonging to a month, which would be the case with the other arrangement.

An inspection of the table will show the fortunate circumstance that all of our present American holidays occur on week-days, with one exception. This is Lincoln's birthday, which comes upon Sunday, February 12. It is perhaps better so, as another holiday, Washington's

birthday, follows so soon, coming on Wednesday, February 22. Decoration Day occurs Thursday, May 30; Independence Day, Wednesday, July 4; Labor Day, Monday, September 4; Columbus Day, Thursday, October 12; Thanksgiving Day, Thursday, November 23 or 30, as may be determined; and Christmas, Monday, December 25; Election Day need no longer be "the first Tuesday after the first Monday in November" but can be fixed simply on November 7. Such movable holidays as Easter and other ecclesiastical dates which are partly dependent upon the moon will, of course, not be fixed; but they will occur more uniformly than at present.

In England May Day will occur on Wednesday, May 1; and Michaelmas on Friday, September 29. In France, their glorious July 14 will always occur upon Saturday.

In the table, the extra day is named "Silvester," as suggested by the European reformers referred to. An alternative arrangement might be made, however, by calling it something else, or by using Christmas Day for this position in the calendar, instead of six days earlier. This need not offend any christian sentiment as this day is often moved now from Sunday to Monday; and there was originally considerable dispute as to where in the year it should be placed, no definite arrangement, I believe, having been made previous to the fifth century. My own preference, however, would be to leave Christmas where it is, and have the extra day as another holiday, replacing our present "new years."

Kalender for 1918, A.D., and ever after

Days in Seasons	Name of Month	Number of Days	Dates of Sundays					Leap Year
Winter......	January.....	31	1	8	15	22	29	
91	February....	30	5	12	19	26		91
	March......	30	3	10	17	24		
Spring......	April.......	31	1	8	15	22	29	
91	May........	30	5	12	19	26		91
	June........	30	3	10	17	24		
Leap Day...								1
Summer.....	July........	31	1	8	15	22	29	
91	August......	30	5	12	19	26		91
	September...	30	3	10	17	24		
Autumn.....	October.....	31	1	8	15	22	29	
91	November...	30	5	12	19	26		91
	December...	30	3	10	17	24		
Silvester.....		1						1
Year........		365						366

Each year, with its first season, first month, first week, first day and first hour to commence at midnight following the winter solstice—in the morning of what we now call December 22. Leap years to be the same as in the Gregorian calendar.

To establish the new calender it would, of course, be necessary to have uniform legislation agreed upon by all the principal civilized nations of the world. They would then simply issue an edict that at a specified future time, the first day of December was to be considered as the tenth and that when the following January 1 arrived the new scheme should commence and remain in force forevermore. Such a ten-day shortening of a month should not frighten any one when it is remembered that this identical proceeding was followed when the Gregorian calendar was established, the change as it happened then also requiring ten days.

When England changed from O.S. to N.S., 170 years afterward, a shortening of the year by eleven days occurred, and nobody seems to have been scared. Of course it could easily be arranged by law that notes and other financial promises and contracts would mature after an expiration of the given number of days of intended duration when they were dated. This little trouble would occur but once, and all things would run smoothly ever after, with a vast improvement in the convenience of reckoning dates and days of all kinds, including our personal birthdays.

The proposed civilization of the calendar might be decreed at any time, but as it will doubtless take years to make the change popular, it might be well to fix upon December, 1918, for a hoped-for performance of the operation. In that year, Saturday falls upon the day of the solstice, December 21. This, when the ten days shortening was made, would be the thirty-first by the new scheme and consequently would be "extra day," "Silvester," or whatever it might be called. The following day being Sunday, would give the start as the first of the new year by the new calendar. Thus, nobody could be prejudiced at the beginning by putting any two Sundays further apart, or nearer together, as would be the case in other years than 1912, 1918, 1924, etc.

In regard to the practical promotion of calendar reform, it would seem as if some of the large scientific bodies of this country should act together, and get into close affiliation with the interested people in Europe, who seem to be farther advanced in their ideas than we are. Thus an influence might be brought to bear upon the various civilized governments of the world which would some time result in victory. Should not an international kalender society be formed in the near future?

BASIL VALENTINE: A SEVENTEENTH-CENTURY HOAX

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ALL who are at all familiar with the early history of chemistry will recall the prominent place given to a writer who wrote under the name of Basil Valentine and in the early history of the sciences was generally assigned to the fifteenth century. His knowledge of chemistry was for that time remarkably advanced, falling chronologically, as it appeared, between the writings of the medieval alchemists, Albertus Magnus, Arnoldus de Villanova, Raimundus Lullus and Roger Bacon, and those of the later authors Paracelsus and Agricola. The histories of chemistry by Ferdinand Hoefer in France 1842–3 and by Hermann Kopp of Germany 1843–7, which have served largely as the basis for later histories of that period, both accepted from earlier sources the works of Basil Valentine as of the latter part of the fifteenth century, though with some evident uncertainty as to this period. Both Kopp and Hoefer mark the work of Basil Valentine as closing the alchemical period, and ascribe to Paracelsus the inauguration of the medical chemical or iatrochemical period.

Examination of the writings of the so-called Basil Valentine and of the writings ascribed to Paracelsus made it apparent that many of the most important facts of chemistry as well as many of the theoretical ideas which Paracelsus announced and made the basis of his revolutionary influence upon chemistry and medicine were contained in the works of Basil Valentine.

Thus to Basilius was awarded the priority of the announcement of many chemical observations and experiments and their applications to the uses of medicine, and to Paracelsus was credited the making of these ideas influential for progress.

Paracelsus was born in 1493 and died in 1541. The chemical literature extant previous to his time and which may claim to be of importance, apart from the slight contributions of the ancients, was comprised in manuscripts or printed books attributed to Gheber, Albertus Magnus, Raimundus Lullus (or Lully), Roger Bacon and Arnoldus de Villanova, though many of these writings are known to be forgeries of much later date than are the genuine writings of these men.

The works of Paracelsus were published, some few during his life time, but most of them from twenty to fifty years after his death. They were collected and published by Huser in Basel in 1589–91,

excluding however his surgical books, which were already, however, in print at that time, or at least the important ones. Many of the writings included in Huser's collected works of Paracelsus are in the opinion of modern scholars not genuine. Huser himself included some which he thought were not genuine. The important point here, however, is that the body of the writings ascribed to Paracelsus was in print by 1591.

There exists no evidence that up to this time any one had ever heard of Basil Valentine. No known reference has been found in any author before 1600, no original manuscript nor copy of probably prior date has been known to exist.

The writings of Paracelsus, or attributed to him, give evidence that he possessed a familiar and extensive knowledge of the chemical facts and experimental methods of his time. He mentions the names of those from whom he learned the art and they are names that are known as students or practical chemists of the period, such as Trithemius, and Sigmund Füger, the miner and mine owner. Paracelsus published many chemical facts and observations which were new to the literature of chemistry. The names of zinc and bismuth appeared to have been first mentioned by him. He characterized these as resembling the metals (that is, the seven ancient metals) and called them bastards of the metals, because they lacked malleability and ductility. He recognized a basis of discrimination between alum and the vitriols, in that while the latter have metals as bases alum has an earth for base, a good distinction for that time. He showed how an amalgam of copper might be obtained by precipitating copper from its "vitriol" (or sulphate) by means of iron and then rubbing the precipitated metal with mercury. He describes the action of oil of vitriol upon iron and notes that "air rises and breaks forth like a wind."[1] He notes the bleaching action of the fumes of sulphur upon red roses, notes the preparation of metallic arsenic "prepared like a metal," and the formation of "fixed arsenic" (non-volatile arsenic acid) by the action of niter upon white arsenic. He first uses the term "reduction" for the preparation of the metals. He mentions the use of an infusion of nut galls for detecting iron in mineral waters and describes the separation of muriatic acid from mixture with nitric acid by the use of silver.

In Paracelsus first appears the theory of the chemical elements which dominated chemical thought until the rise of the phlogiston theory, viz., the notion that all substances are composed of the three elements mercury, sulphur and salt. From Gheber, Lullus and others of his predecessors he was familiar with the notion that mercury and sulphur were constituents of the metals, but he extended the theory and gave it a more consistent form by interpreting the mercury as the

[1] Hoefer, "Histoire de la Chimie," 2d ed., II., p. 12.

element which gives volatility, sulphur as that which burns, and salt as that which neither burns nor volatilizes in the heat.

Paracelsus also used and advocated the use of many metallic preparations for medicines, as preparations of mercury, antimony, lead and arsenic. He recognized the poisonous character of them when used in excess, but emphasizes that poisons may be used to advantage in medicine in proper doses.

These and similar announcements scattered through his writings marked Paracelsus as a chemist of importance, if they were derived from his own experience, and not borrowed from some other source.

But Paracelsus was a physician who had incurred the antagonism and enmity of the great majority of the orthodox medical profession. He had repudiated the doctrines of Galen and Avicenna, their almost sacred authorities. He held their knowledge up to contempt in lecture and in writings and savagely attacked the practises and the ethics of the profession. Their opposition he met with arrogant defiance. As his following increased, the warfare between the Galenists and the Paracelsists increased in bitterness, and for a century after his death the contest continued with bitterness. The result was a partial victory for the chemical medicines introduced by Paracelsus, but there also resulted a gradual discrediting of Paracelsus by the growth of a mass of legends derogatory of his ability and character, most of which have since been shown to be baseless, but which his faults and weaknesses served to make credible. While this warfare was still at its height, at the beginning of the seventeenth century, there appeared a number of printed books, published by Johann Thölde, purporting to be from old manuscripts and to be written by a monk of the Benedictine order—Basilius Valentinus. By far the most important of these was the "Triumph-wagen des Antimons," or "Triumphal Chariot of Antimony," (1604), which contained, with much that was mystical and obscure, as was the fashion of most chemical literature of the time, nevertheless a remarkably clear treatment of the preparation and properties of many compounds of antimony, and of their application to medicine. This work attracted deserved attention, and other works which appeared under the same author's name about the same time and later shared in this popularity. That all of these were by the same hand as the "Chariot" is certainly not true, especially the later publications.

It was soon noticed that nearly all the above mentioned contributions of Paracelsus to chemistry were contained in the work of the newly discovered author, and often more thoroughly explained and more comprehensively treated than in Paracelsus, though sometimes the opposite was the case.

Basil Valentine had also spoken of zinc and bismuth and called them bastards of the metals. He had also noted the action of oil of

vitriol upon iron, though he made no mention of the escape of "air" in the process. And so with most of the above mentioned experimental data of Paracelsus. Basil Valentine had also announced the doctrine of the three elements—mercury, sulphur and salt—though he had not made the interpretation of their significance as qualities of bodies as had Paracelsus. Basil Valentine had also advocated the use of metallic preparations of antimony, mercury, etc., in medicine, and he also had abused and ridiculed the physicians of his time.

Indeed, to any one who compares the many similar data and ideas in the two collected writings the conclusion seems unavoidable that one of these authors drew from the other, or else that both drew from the same common third source. But no such common source was known or is yet known. If then the writings of Basil Valentine were authentic and of the fifteenth century as assumed, then assuredly Paracelsus must have had access to a copy of the manuscripts and have freely utilized the contents without reference to the author. As he freely refers to other authors in approval or disapproval, this omission was notable. If the writings of Basilius were forgeries of the time of the publication, then they were written some sixty years after the death of Paracelsus and were borrowed not only from him, but presumably also from Agricola and minor writers whose works appeared in the latter half of the sixteenth century.

In favor of the genuine character of the newly published author spoke the real value of the contributions in the "Triumphal Chariot." Why should any one who could write such a work conceal his identity and lose the credit for it by attributing it to another? It was not probable. This conclusion was doubtless also encouraged by the disrepute in which the name of Paracelsus was held by the medical profession and the scholarly classes of the time. Here was an explanation for the apparently profound knowledge of chemistry which Paracelsus seemed to possess, but to whom they gave no credit for scholarship of any kind.

Doubtless also the name and standing of the editor and presumptive possessor of the original manuscript, Johann Thölde, a chemist, owner in the salt-works at Franckenhausen in Thuringia, and member of the Chamber of Councilors (Rathskämmerer), gave additional presumption of the genuineness of the find.

Against the originality of the writings in so far as they were to be assigned to an earlier century, was in the first place the fact that previous to their publication by Thölde no knowledge existed of any such person as Basilius Valentinus. No writer of the fifteenth or sixteenth century had referred to any such author.

Examination of the records of the order of St. Benedict in Germany or at Rome failed to discover any such name on the rolls. No original manuscript was preserved or placed in evidence at any time.

Thölde explained in his preface to one of the early publications that it was from a very old manuscript which he had great difficulty in deciphering and translating from the original Latin script. From the evidence of the books themselves little could be learned. The author claimed to be of German nationality from the region of the Rhine, and to be an inmate of a Benedictine monastery and a brother of that order. They contained no reference to any contemporary persons or events which might serve to locate their exact time.

From allusions to the use of antimony in the making of types for printing, it became evident that the date of the writing was not earlier than the latter half of the fifteenth century, and from several allusions to the application of chemical medicines to the cure of the "Morbus Gallicus" (or "French Disease") which was known to have made its appearance in Europe about the end of that century (1493 is the date usually quoted) it was evident that the writing could not have been earlier than about the close of the fifteenth century. While this internal evidence established the end of the fifteenth century as the earliest possible date no internal evidence indicated that the date of the authorship was necessarily earlier than the date of publication. Though there have apparently always been critics who have disputed the genuineness of the find,[2] yet the general opinion gained credence and authority that Basil Valentine was the assumed name of an unknown writer of the end of the fifteenth century, and that to him, therefore, was to be credited the priority of announcement of a large part of the more prominent facts and theories of chemistry which already existed in print in the works of Paracelsus. It was taken for granted and asserted that Paracelsus had had access to a copy of his works or of some of them, and therefore had appropriated his ideas without acknowledgment. No less an authority than van Helmont (1577–1644) states that Paracelsus lived more than a hundred years after Basil Valentine and had appropriated his knowledge without due credit.[3]

In time also certain legends grew up and became adopted into current literature which seemed to give a greater definiteness to the existence of the assumed author. Gudenus in his history of Erfurt (1675) stated that a monk of that name was a member of the Benedictine order in that city in 1413. Though Gudenus cited no authority for this statement, and the records of the monastery gave no confirmation, and though, for reasons above mentioned, the works of Basil Valentine could not have been written before the end of the century,

[2] Ferguson, "Bibliotheca Chemica," 1906, mentions Stolle, 1731, Kestner, 1740, the author of "Beytrag zur Geschichte d. Höheren Chemie," 1785. Waite ("The Triumphal Chariot of Antimony," London, 1893) quotes Placcius, 1708, as skeptical of B. Valentine.

[3] Cf. Van Helmont, "Opera Omnia." Francofurti, 1682. "Tria Prima Chym.," p. 386.

yet this statement added in time a certain weight to the belief in his reality. Still later apparently arose a tradition that in 1515 the Emperor Maximilian I. had instituted a search to establish the identity or existence of the alleged Basil Valentine, though with negative results.[4] This statement found its way into most of the histories of chemistry and is still frequently met with. The importance of the acceptance of the statement lies in the fact that it assumes that at that early date Basil Valentine was known and an object of interest, instead of a century later. Kopp, who in his "History" (1843) repeats and credits the statement, in his "Beiträge" (1875) calls attention to the baselessness of the rumor.[5] It may be that there is confusion here between the Emperor Maximilian I. (1459–1519), and Duke Maximilian I. of Bavaria (1573–1651). (This explanation has been suggested, though the writer can not now locate the source of the suggestion.)

The question of priority in important contributions to the history of chemistry and the question as to plagiarism by Paracelsus or imposture by Thölde both hinge upon the fact as to whether the Basilius writings were written about 1500 or about 1600, and from what has preceded it would seem that the presumption is in favor of the latter date and that the burden of proof lies with the supporters of Basil Valentine.

But the evidence is not closed with the above-mentioned considerations. Though in his "History of Chemistry," Kopp had accepted the prevalent view that the writings of Basil Valentine were of earlier date than those of Paracelsus, his researches did not cease with the publication of that work. In 1875 in his above quoted "Beiträge zur Geschichte der Chemie" he entered anew and in great detail into the problem. One by one he traces back through the literature the sources of the traditional statements upon which are founded the supposed identification of the period of Basil Valentine. His continued investigations of the manuscripts in the libraries had failed to develop any originals or copies of apparently earlier date than the printed works. He announces his opinion that the evidence favors the judgment that the works of the supposed Basil Valentine are of later date than Paracelsus rather than earlier. He hesitates, however, to accuse Thölde himself of intentional deception, as nothing was known against his reputation, and it could hardly be supposed that he would not have published such a work as the antimony monograph under his own name if he really wrote it.

Eleven years later (1886) in his latest work, "Die Alchemie," and as the result of failure in the meantime to obtain from any source any evidence favoring the prevalent theory, he reiterates more decidedly his

[4] Schmieder ("Geschichte d. Alchimie," 1832), who refers to Motschmann, "Erfordia literata," Erfurt, 1729–32.

[5] Kopp, "Beiträge," III., p. 112.

belief in the fraudulent character of the work and that Thölde himself was the writer as well as the editor of the alleged Basil Valentine works. With reference to this Thölde, Professor John Ferguson, of the University of Glasgow, the first of British students of chemical literature of this period, in his "Bibliotheca Chemica" (1906), gives some pertinent information and ideas.

Ferguson calls attention to the fact that Thölde published a work in his own name "Haliographia," on salts, salt works, etc. (1603). It consists of four parts. Ferguson says:

> This fourth part, it is said, appeared in 1618[6] with the name of Basilius Valentinus. It was certainly published at Bologna, 1644, ''Ex manuscriptis et originalibus Fratri Basilii Valentini ordinis S. Benedicti collecta,'' without any mention of Thölde. This may be all quite straight, but somehow it needs explanation. Especially when we remember that the works of Basil Valentine are said to have been not merely edited by Thölde but actually written by him. It is a dilemma; either Thölde had appropriated the work of Basil Valentine without acknowledgment, or else he has put out or allowed to be put out, a work of his own under the name of Basil Valentine. In his discussion of this subject in the ''Beiträge z. Gesch. d. Chemie,'' Kopp has occasion to consider the connection between Basil Valentine and his reputed editor, and he is inclined to regard Thölde as editor merely, on the ground that as the works contain a good deal of chemistry that was new for the period, he can not see why Thölde should have ascribed that knowledge to one to whom it did not really appertain. He considers that there is nothing in Thölde's life otherwise which would give occasion to believe him untrustworthy. Well, he may have been quite an honest man, but appearances are rather against him and one can sympathize with Dr. Caius: ''What shall de honest man do in my closet? Dere is no honest man dat shall come in my closet!'' It makes one suspicious that if Thölde could tacitly absorb into his ''Haliographia'' without acknowledgment a tract which afterwards appeared under Basil Valentine's name, there is no reason why he should not have used the name of Basil Valentine all along as a stalking horse and under presentation of that shot his alchemy. But on this occasion he had forgotten his pseudonymity.
>
> Subsequently (''Die Alchemie,'' 1886, I., pp. 29–33) Kopp changed his views regarding Thölde and Basil Valentine, and said that there is reason to think that the writings of the latter were composed about the end of the sixteenth or the beginning of the seventeenth century instead of a hundred years earlier; that Basil Valentine's name is fictitious; that the publication of these writings was an intentional literary deception; and in that case that the responsibility must rest with Thölde. It is very remarkable that in this view, so decidedly, uncompromisingly, different from that enunciated by him eleven years earlier he should have come to exactly the same result as that elaborated one hundred years earlier and expressed with emphasis by the author of ''Beytrag,'' a work which, so far as I have observed, was unknown to Kopp, as I do not think that he ever refers to it.

Professor Ferguson in his comments on Kopp's change of views between 1875 and 1886 seems to have overlooked or forgotten that even

[6] Schmieder, ''Geschichte der Alchemie,'' in his bibliography of Basil Valentine gives 1612 and 1644 as dates of these editions.

in 1875, while he was disposed to acquit Thölde of the authorship, he nevertheless clearly expressed his opinion that the authorship followed rather than preceded the time of Paracelsus.[7] Eleven years later, however, after failing to find new evidence from any source, he comes to the conclusion that the most reasonable assumption is that Thölde himself was the author. There is therefore nothing "uncompromisingly" different in his views at the two periods rather is it a case of the carefully guarded expression of a gradually maturing conviction. It is not without significance in connection with this Thölde to note that he also published (1605) an alleged "Kleine Hand-Bibel, etc.," of Paracelsus, claimed by Thölde to have been reproduced from a long-hidden manuscript of Paracelsus. Sudhoff in his bibliography of Paracelsus[8] pronounces this an undoubted imposture, reserving for another place the discussion as to whether Thölde were himself the author. This discussion, however, I have not met with.

Since Kopp's time other competent students of the science of that period have come to similar conclusions. Thus M. Berthelot[9] referring to "antimony," says that this name is far earlier than the mythical personage called Basil Valentine, to whom has sometimes been attributed the discovery of this substance, and under whose name have appeared various works which did not appear previous to the sixteenth century.

Dr. Karl Sudhoff, the eminent student of the early history of medicine and author of the monumental bibliography of the literature of Paracelsus, and whose researches into the books and manuscripts of the period in question have been most exhaustive, covering many years of labor, has recently[10] unquestionably assigned Basil Valentine's writings to the beginning of the seventeenth century.

Dr. Franz Strunz, another well-known scholar in the history of chemistry and natural philosophy of the medieval and renaissance periods, asserts with similar conviction:[11]

> The writings of the so-called Basil Valentine, who never existed at all, are by Joh. Thölde. He, however, was in post-Paracelsan time.

Mention may also be made of Lasswitz[12] and Lehmann,[13] amongst modern students of the period who have expressed themselves as accepting the post-Paracelsus origin of the Basil Valentine literature.

It would seem, therefore, in the light of this evidence and in the

[7] "Beiträge z. Ges. d. Chemie," III., pp. 117–119.

[8] "Versuch einer Kritik der Echtheit der Paracelsichen Schriften," I., 465.

[9] "Introdn. a l'étude de la Chimie," p. 279.

[10] "Beiträge aus der Geschichte der Chemie, dem Gedächtniss von G. W. A. Kahlbaum," 1909, p. 254.

[11] In his "Paracelsus, Leben und Persönlichkeit," 1903, p. 30.

[12] "Geschichte der Atomistik," etc., 1896.

[13] "Aberglaube und Zauberei," 1908.

absence of any support but tradition for the reality of a fifteenth-century writer under the name or pseudonym of Basil Valentine, that we are not only justified, but in justice obliged to conclude that the works in question were written at or about the period of their production; that in all probability Joh. Thölde was the author of the more important and earlier ones; that Paracelsus was not guilty of stealing his chemical knowledge from a unique copy of some unknown original, and that not Basil Valentine nor Thölde, but Paracelsus, was the first recorder, if not the first discoverer, of a considerable series of chemical facts, and the originator of some influential theories and applications, which appeared for the first time in his publications.

But the established channels of three centuries of chemical tradition are hard to divert. Despite the verdict of modern scholarship, recent text-books and manuals of the history of chemical science are slow to accept and assimilate the changes involved.

Thus, in the "History of Chemistry," by F. P. Armitage (1906), it is still assumed that Basil Valentine or some one writing under that name lived at the end of the fifteenth century, and consequently such statements occur as the following:

> With Valentine's successor, Paracelsus, there begins a new school of chemistry.
>
> Accepting Valentine's philosophy of the three elements, mercury, sulphur and salt and like him reading this into all matter indiscriminately, Paracelsus was able to give a theoretic basis to his sense of pathologic phenomena.

So also Hugo Bauer (translation of R. V. Stanford, "History of Chemistry," 1907), while stating that "new life was brought into this ruinous state of affairs in the second half of the seventeenth century[14] by Basil Valentine," yet says:

> The most decisive influence upon chemical thought in this period proceeded from the physician Paracelsus, and his successors Van Helmont and de Boe Sylvius. Basil Valentine had already put forth the view that all substances consisted of the three elements sulphur, mercury and salt.

Bauer also gives much space to the chemical work of Basil Valentine and overlooks the similar work of Paracelsus.

Sir Edward Thorpe[15] refrains from assigning any definite period to Basil Valentine, saying:

> He was supposed to be a Benedictine monk who lived in Saxony during the latter half of the fifteenth century: but there are grounds for the belief that the numerous writings ascribed to him are in reality the work of various hands. The attempt made by Maxmilian I. to discover the identity of the author was unavailing, nor have subsequent inquiries had any better result.

Thorpe, however, gives a summary of the more important chemical

[14] This may be a misprint for the fifteenth. The subsequent method and order of treatment would bear out such a supposition.

[15] "History of Chemistry," 1909.

facts from these writings, and in the later references to Paracelsus, which are in line with the judgments of earlier rather than of recent scholarship, no reference is made to the similar contributions of Paracelsus, thus conveying the inference of the priority of the works of the pseudo-Basilius.

Even Ernst von Meyer,[16] whose text-book is deservedly the most popular of recent histories, has not broken loose from the traditional mode of treatment. Referring to the writings in question, he recognizes that "their genuineness has become more and more questioned, and rightly so." But perhaps misled by the alleged "investigations, which were carried out at the command of the Emperor Maximilian I.," he still assumes that "a large number of facts were recorded by the writer, who lived about a hundred years before the books were published."

This rumor of the investigations by the Emperor Maximilian I. (who died 1519) which, as above stated, Kopp has pronounced without substantiation, is the most persistent of the traditions which have served to give the impression that the Basil Valentine literature is antecedent to Paracelsus. Naturally enough, accepting the truth of this statement, Meyer omits from his treatment of Paracelsus the enumeration of chemical data previously noted in Basil Valentine, and in referring, for instance, to the doctrine of the three elements, which to the best of our knowledge was original with Paracelsus he says:

> With respect to the constituents of organic bodies Paracelsus adhered to the old assumption that the latter were composed of the three elementary substance-forming qualities (elements) mercury (Mercurius), sulphur and salt.

In view of the results of the scholarly researches into the history of this period during the past thirty years by Kopp, Berthelot, Sudhoff, Strunz, Lasswitz and others, it is time that the Basil Valentine literature should be assigned to its proper and subordinate place in history. There is indeed great need of a thorough revision of the history of chemical discoveries and theories from the earliest times up to the rise of the phlogistic theory. The task will be no easy one, but the value of the work thoroughly done will well repay the labor.

[16] "History of Chemistry," 3d edition, translated by McGowan, 1906.

THE HINDU-ARABIC NUMERALS*

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AT present the Hindu-Arabic numerals hold nearly unlimited sway in the realm of number. In China, in Japan, in southeast Asia, and in parts of India, it is true, they are employed only by the upper classes and by foreign traders; but all over Europe, in Australia, and in North America, they are supreme; while in South America and in Africa they are used wherever civilized men make arithmetical computation.

Scarcely ever has a more wonderful device been perfected. By means of these characters prodigious calculations can be made. Through tables, logarithms, and counting-machines amazing swiftness and accuracy are obtained. Their power and their scope seem almost limitless.

And yet there was a time when they were confined to a few districts in India, and not heard of by the rest of mankind; when they were cumbersome and inert and difficult to use; when they were no better than number signs which had been developed elsewhere, and not nearly so well known. Even when their superiority was manifest, their progress into other lands was uncertain, difficult, and slow. The story of the development of the Hindu numerals and of their conquest of the world make an interesting but oft-forgotten chapter in the history of civilization.

The idea of number originates in sense experience. The conception of *two* and *three* as different from *one* rests fundamentally upon experience in dealing with one thing and with more than one thing. The ideas of an object and of several objects which the mind forms through the eye or through the sense of touch constitute the basis upon which all knowledge of number rests. Thus gradually in infancy or during the childhood of the race are obtained the conceptions of what we now call in English "one," "two," and "three."

In the lower stages of culture only dim ideas of higher number exist, and the lowest, basic numbers are used in combination to express

* In preparing this paper I have had the assistance of Dr. Louis Charles Karpinski, who has put at my disposal the results of research in a field which he is making peculiarly his own. By permission of Messrs. Ginn several illustrations are reproduced from Smith and Karpinski, "The Hindu-Arabic Numerals," Ginn and Company, 1911, the best work upon the subject, and a work of which I have made free use.

what is more numerous. Thus, three and one or three and two take the place of four and five. This method was actually incorporated into the systems of the Phenicians and the ancient Hindus. Indeed, the habit persists in the minds of people later on, when they possess many number symbols and the ability to use them in calculation. While the more acute nowadays can without great difficulty comprehend four and five, yet five will frequently be apprehended better as a combination of two and three, while almost inevitably six will be thought of as a combination of three and three, and seven as made of three and four.

Nevertheless as the mind of man becomes more powerful, and the need for calculation becomes more frequent, larger numbers are made use of, even though they can only be comprehended as combinations of smaller ones. The designation of these number ideas soon becomes necessary, and it must be made both for the eye and for the ear. For the eye this may be done by symbols; for the ear by words. Thus, the Greeks may write ϙ′ (90) and call it ἐνενήκοντα; the Romans XL, and call it *quadraginta*.

The designation of these number ideas either by symbol or by sound is exceedingly difficult for the reason that number ideas are necessarily abstract. It is true that the lower, which represent a few objects, can be designated by pictures. So, man may originate the symbols for his lower numbers in the same manner that he first makes the symbols for his words, by ideographs or picture-drawings. In old Chinese the rude representation of a man designates man. Similarly the Chinaman writes a simple stroke to represent a single object; two strokes to represent two objects; and three, to represent three:

一 二 三

The Hindu once employed the same device, except that his strokes were usually perpendicular:

I II III

These symbols were used wherever men began to write their numbers. They were employed by the Latin peoples, and as the Roman numerals are still in common use. In cursive form they are the numerals which we use to-day:

Such graphic designation of number cannot be carried very far, however, and arbitrary symbols must soon be employed. Thus, for four the Hindu wrote two strokes crossed:

×

Whether this is a combination of four strokes, and so a true ideograph, can not be known. For six the Chinaman writes

六

Thus a series of signs may be accumulated.

In many cases the need for a series of number symbols arises when considerable progress has been made in the construction of an alphabet. The alphabet then furnishes a series of signs which follow each other in definite sequence, and as signs are fairly well understood and familiar. The result is that the letters of the alphabet are employed to designate the number ideas. This was done by the Hebrews, who make use of their twenty-two letters, and by the Greeks who had the twenty-four letters of their alphabet with three archaic signs interspersed.

As an example of this alphabetic designation the Greek system may be taken. The letters accented were the numerals: α′. 1; β′, 2; γ′, 3; δ′, 4; ε′, 5; ς′, 6; ζ′, 7; η′, 8; θ′, 9; ι′, 10; κ′, 20; λ′, 30: μ′, 40; ν′, 50; ξ′, 60; ο′, 70: π′, 80; ϙ′, 90; ρ′, 100; σ′, 200; τ′, 300; υ′, 400; φ′, 500; χ′, 600; ψ′, 700; ω′, 800. The intervening numbers were expressed by combination; thus, $\gamma' = 3$ and $\iota' = 10$, therefore $\iota\gamma' = 13$; while the numbers for the thousands were expressed by sub-accenting the lower symbols; thus $\beta' = 2$, $_{,}\beta = 2000$.

Here is a system comprehensive and excellent for the mere writing of numbers. It was, however, because of the numerous signs employed, cumbersome and complex. For example, in multiplication, where our nine numerals now in use require a knowledge of forty-five combinations—one times one, one times two, one times three, and so on—the Greek system with its twenty-seven characters required the memorizing of three hundred and seventy-eight—α′ times α′, α′ times β′, α times γ′, and so forth. Other arithmetical processes were correspondingly difficult.

Another scheme, apparently much simpler, consists in using only a few letters or signs. As an example, the Roman system may be taken. For one a single stroke was employed, I; while groups of strokes were used for the numbers following, II, III, IIII. Five was designated by a symbol of its own, V, which was once thought to be a representation of the thumb and four fingers held up, but this theory has been abandoned. For ten, X was employed, the origin of which is not entirely clear. A study of the inscriptions, however, affords ground for the belief that the Romans in counting from one to ten used one, two, three, four, five, six, seven, eight, nine strokes; then, to avoid

confusion, denoted ten by drawing a tenth stroke over the nine parallel ones,

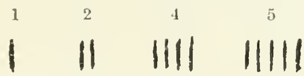
and that this was abbreviated to two strokes crossed, X. The upholders of this theory assert that five, half of ten, was then denoted by V, half of X. For fifty, L was used: for one hundred, C; for five hundred, D; for one thousand, M. The numbers in between were expressed by combination: LX = 60, DCXV = 615; or by addition to or subtraction from the nearest one of the seven symbols: XII = 12, IX = 9.

The advantage of this system lay in the fewness of the symbols employed. Where the Hebrew had twenty-two characters and the Greek twenty-seven, the Roman made use only of seven. Because of this fewness the value of the characters could be easily remembered. On the other hand the smaller number of characters employed made necessary the greater use of combination. The Greeks had a symbol for sixty or for ninety, but the Latins must place together several numeral signs of smaller value so that the combination would equal the total required In Greek 60 might be expressed by ξ', one character; in Latin by two, LX. The more complex the number the greater became the relative cumbersomeness of the method. In Greek 1863 could be expressed by $,\alpha\omega\xi\gamma'$; in Latin it would be MDCCCLXIII. The result of these cumbersome combinations was that with the Roman numerals it was virtually impossible to make calculations of any intricacy, and exceedingly difficult to make even simple ones. They might be employed for mere designation, as they are to this day used to express dates and to distinguish the pages of a preface: but for addition, subtraction, multiplication, division, and intricate arithmetical work, the Roman mathematicians were driven to use the Greek symbols and methods.

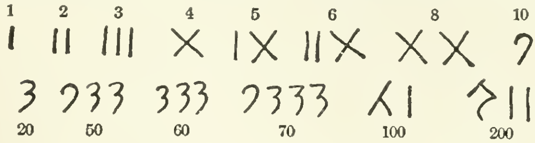
Meanwhile in the east other systems of numeral notation had been developed, some of which, in modified form, are in use there at the present time. The Babylonians were expert calculators; and the Chinese invented a notation which they still have. It was in India, however, that a system arose destined to supersede all others among civilized people.

There were probably some numerals in use among the Hindus a thousand or more years before our era, but no records exist earlier than the time of Asoka, in the third century B.C. From this time on occur inscriptions which contain some of the native number symbols. Two systems may be discerned, which possess respectively the characteristics of the Roman and the Greek.

In the Kharosthi inscriptions of the third century B.C. four numerals occur, the origin and meaning of which are evident:

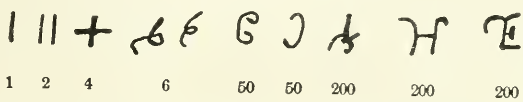


In the Saka inscriptions of the first century before Christ more characters appear, and the resemblance to the Roman becomes striking:*

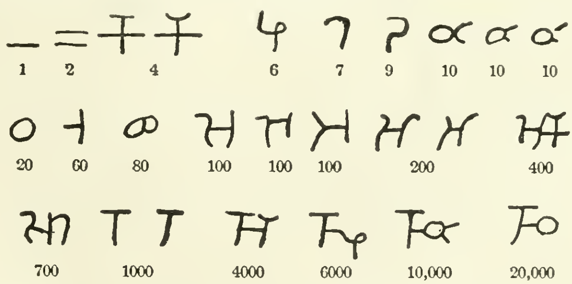


This system is constructed of the symbols for 1, 4, 10, 20, 100, and so forth, as the Roman is built upon the I, V, X, L, C, D, and M.

In the same period another system was invented in which greater flexibility and power were obtained by using an increased number of signs. In the third century B.C. certain of King Asoka's inscriptions in the Brahmi writing contain these characters:*



In the following century an inscription in the Nana Ghat cave near Poona in central India has even more interesting ones:*



Here the 1, 6, and 7, which we now use, appear plainly; while the 2 and 9 are in rudimentary form. About two hundred years later inscriptions in the Nasik cave contain all of the important Hindu numerals:*

* From Smith and Karpinski, "The Hindu-Arabic Numerals."

Here the characters for 1, 4, 6, and 7 are easily recognizable, while the 2, 3, 5, and 9 can be developed without difficulty.

This system is neither different from that of the Greeks nor superior to it. Neither has a zero, and in neither have the characters a value of place. That is, all of the important numbers must be designated by signs of their own. In our system 2 moved one place to the left becomes 20, but in Greek $\beta' = 2$ and $\kappa' = 20$. So, in the Nasik inscription 2 and 20 are designated by characters separate and distinct.

In this far there is similarity; but while the Greeks used the letters of their alphabet, the Hindus did not. The meaning of some of these signs, such as the strokes for 1, 2, and 3, is apparent, but the origin and meaning of others are not known. They may have been made from alphabetic characters, but as yet no theory has been substantiated.

It may be seen that all of the different systems of numerical notation which had been developed, whether in China, in India, or in Greece, had the same general characteristics: there was no zero, and the symbols had no place value. Because of this it was necessary to employ a great many different symbols. Such a system might be used for mathematical calculation, but it was bound to be complicated and intricate. What was needed was a system with fewer signs; but when this was constructed, as it was among the Romans, and the Greeks of Solon's time, it was so rigid and inflexible as to admit of no progress in mathematics. Something altogether different was needed.

Gradually, by processes of which we know little, a revolution was wrought in all mathematical work and new numeral systems were developed. This revolution was effected by the use of the counting-board, or, as we now call it, the abacus, from a Greek word the meaning of which is in dispute. At first all calculation was probably mental or performed upon the fingers, but as time went by, a mechanical device was perfected wherever men strove to make readier and more elaborate computations. This device is said to have been invented by the Chinese, though of such tradition there is no certain proof At all events it was used by the Chinese, the Babylonians, and the Hindus in immemorial times. The Greeks and the Romans had it; and it continued to be used in Europe throughout the middle ages. According to the "Dialogus de Scaccario" of the twelfth century, the officials of the exchequer reckoned the king of England's revenue by means of it. To this day it is employed generally in Russia, and in schools wherever children are learning to count.

Fundamentally the abacus consists of a board or table marked off in parallel columns within which counters can be placed. The principle is the same if the counters are strung along parallel wires. The important thing is that on the abacus each column has a value of its own, a *value of place.* Thus, several numerals may be employed with

reference to the counters in the first column, for example, our 1, 2, 3, 4, 5, 6, 7, 8, 9. Then these same numerals may be employed for the second, but they will now have in their new place a new value, let us say, ten times as great, so that a 2 in the second column will denote 2 tens, or 20. And so in other columns, which give the value of 100, or 1000. By this means the entire number of numeral signs may at once be reduced to the number of signs used in the first column. Without the abacus the Greeks must have nineteen signs in counting from one to a hundred: on the abacus there is need only of nine.

The place value assigned on such an instrument would depend upon the practical system of counting which had been developed. Just as nowadays the workman, or the boy playing a game, will tally five, and then begin another five, and then another, thus making a group of fives which he can handle easily, rather than one longer series, so the practical calculators of bygone days worked with fives, or sixes, or tens, or twenties. Various systems have been used. The Babylonians employed the sexagesimal, reckoning by sixties. Some of the African tribes count by sixes, and some of the New Zealanders are said to use elevens. The duodecimal or twelve system has passed away, but in the *dozen* we still preserve traces of it ourselves.

As a rule, however, the system has been none of these, but counting has been done by fives, by tens, or twenties, and this simply because it has been based upon the antique but persistent habit which man has of counting upon his fingers. To this day there is a widespread custom of reckoning roughly by fives. The Mayas of Yucatan used the vigesimal or twenty system; so did the men of Palmyra in Zenobia's time, and the Syrians before the days of Mohammed. The same is said to have been true of the Celts, and the French seem to preserve traces of it now when they say *quatre-vingts,* four twenties, for 80. But after all that system which has been most widely adopted is the decimal, based upon all the fingers of the two hands.

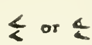
The Hindus came to employ the decimal system, as did the Greeks and the Chinese. It found place in the written language as well as in the numeral notation; but, as has been said, it existed only in complicated form. Thus, the Greeks and the Romans had words to express numbers from one to ten, as they had signs. In Greek εἷς and α′ denoted one; δέκα and ι′, ten; after which there were words and signs for twenty, thirty, and so on, at intervals of ten up to one hundred; followed by words and signs at intervals of a hundred. In between, the numbers were expressed by combination: ἕνδεκα (one-ten), eleven; δύο καὶ τριάκοντα (two and thirty), thirty-two. The Roman system was entirely similar, except that it employed fewer signs. The Hindus used the decimal system even more consistently, since they preserved it in counting beyond thousands indefinitely.

Thus, the decimal system was developed in language and in numeral notation at the same time that it was being employed in the construction of the abacus. In each case its origin was due to the habit or practise among people of counting upon the ten fingers until they came by custom to reckon in tens. In each case, however, the decimal system was unwieldy in that it was built up upon a large number of words and signs. It was the function of the abacus to make it simple by reducing the number of signs.

Since the Hindus employed the decimal system, so, on an Indian counting device the counters in the second column had ten times the value of those in the first; the ones in the third ten times the value of those in the second, and one hundred times the value of the counters in the first. It was necessary now for the Hindus to use only the signs which in their present form are 1, 2, 3, 4, 5, 6, 7, 8, 9. Thus, 591 would be represented by 5 | 9 | 1. In like manner 501 would be 5 | | 1, the middle space being vacant since there were only five hundreds and one unit, but no tens. Among the Greeks it is probable that the same method was worked out. In this manner the number signs could now be attached to a definite place, and so had a definite place value. This is the most important step which has ever been made in mathematical science.

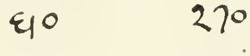
But a difficulty arose when the calculation was transferred from the abacus-board and became a written operation. 591 could be transferred without difficulty, since the digits by mere juxtaposition would preserve their place value; but 5(0)1 taken from the abacus might be 51, since the *vacant* place was no longer indicated. Accordingly mathematicians were led to invent a character to stand for the vacant space. By so doing they perfected the system of place value, since they could now show that even when there was no one of the nine numerals in a particular place, the value of the place remained, and the values of the adjoining places could be maintained. The invention of a symbol for nothing is the crowning, transcendent achievement in the perfection of the decimal system, and lies at the base of all subsequent arithmetical progress. It is the peculiar triumph of the Hindu mathematicians to have made this contribution to the science of number.

A symbol for nothing was employed among the Chaldeans, but merely for notation, and apparently never in calculating. In the cuneiform incriptions it occurs as



Among the Hindus it was at first a dot (.). In this guise it was borrowed by the Arabs, who still use it. Very soon, however, the Hindus began to employ a circle, 0. The earliest known use is in an inscrip-

tion at Gwalior, 876 A.D. Fifty and two hundred and seventy are written respectively

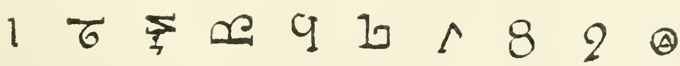


So at last the decimal system was complete, and it had been worked cut in the Hindu numerals. It remained now to carry them from India into the countries nearby.

The introduction of the Hindu numerals into Europe is one of the obscurest matters in history. Most probably the truth can never be completely discovered. This is as it should be, since the adoption of these numerals was natural and slow, and not premeditated or artificial. After a while they were in use among the merchants of the east, who carried them along the highways of the world's commerce It may be that they entered into countries upon bales of goods or in the accounts of traders, and so would be unnoticed by the scholars. Perhaps for a long time the local mathematicians would know nothing of them, and would continue to use the symbols and the systems of their forefathers. It may be said, however, that the fame of the Hindu characters was spreading into the countries near by even before the addition of the zero. In 662 Sebocht, a Syrian ecclesiastic, writing in a monastery on the Euphrates, refers to the "science of the Hindus . . . and of the easy method of their calculations, and of their computation, which surpasses words. I mean that made with nine symbols." No doubt there were others in the neighboring lands who came to know of this wondrous art.

Of one thing there is no doubt: the Arabs soon adopted the Hindu numerals, and when they spread their conquest across the world they carried these numerals with them. In the ninth century a group of brilliant mathematicians were employing them at Bagdad, while a long line of scholars used them in a slightly different form, the *Gobar* numerals, in Spain. From the Arabs these numbers were taken by Christian Europe, and for this reason came to be known for a long time as Arabic numbers.

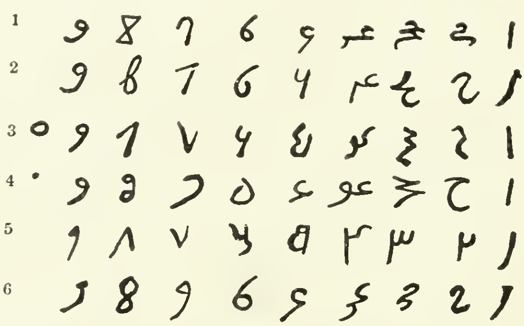
There will always be the question whether in some form these numerals were known and used in southern Europe before the coming of the Arabs. It is not likely that this matter can ever be entirely determined. In an eleventh century manuscript of the "Geometry" of Boethius there is a passage where certain numerals are introduced, curiously like the Hindu symbols:



As Boethius wrote at the beginning of the sixth century this was at one time thought to indicate an early introduction of the symbols, or

even an independent origin; but it is now as certain as such things can be, that the passage is a medieval interpolation, and was not written by Boethius. The subject is exceedingly obscure, but there is reason for thinking that these characters, *apices,* as they were called, were used in Europe some time before the interpolation was made.

However this may be, there was apparently among the Christian peoples of Europe no widespread use of the ten symbols as they were used by the Hindus, until the Christians borrowed them from the Saracens of Spain. The date of their introduction from Spain cannot be determined, but it is fairly certain that Gerbert, who as Sylvester II. was Pope from 999 to 1003, brought them back from the Saracens among whom he had studied. He seems to have described the nine Gobar numerals without the zero:*



After a while some of the monkish mathematicians learned of the symbol for nothing. O'Creat in the twelfth century employed it in three forms, o, ō, τ. At this time when the new numerals are used the whole subject is confused. Sometimes the Hindu symbols are used without the zero; sometimes the Roman characters with it, the Roman characters then acquiring a place value. Thus, when O'Creat writes 1200, he puts it I.II.τ.τ.; for 1089 he uses I. O. VIII.IX. At the beginning of the twelfth century Radulph of Laon used a mixture of Gobar and Roman characters. About the same time an unknown German scribe wrote them in a manuscript now in the Hof-Bibliothek in Vienna.

The mathematician who had most to do with spreading the Hindu numerals in Europe was Leonardo Fibonacci, a merchant of Pisa, who was born in 1175. In 1202 he completed his "Liber Abaci," or arithmetic, rewriting it in 1228. He it was who, when employing the Hindu numerals, first clearly explained their use. The progress was furthered when Alexander de Villa Dei about 1240, and Johannes de Sacrobosco about 1250, wrote popular treatises. Of Sacrobosco's "Algorismus" there remain now nearly one hundred manuscripts. It was due to him particularly that the Hindu signs came to be known in Europe as *Arabic numerals.*

* From Smith and Karpinski, "The Hindu-Arabic Numerals."

The Hindu characters were now known, but they came into general use very slowly, for the same reason that the metric system is not adopted immediately nowadays. The Roman characters, computation on the abacus, and various devices held their own obstinately through force of custom. Moreover, before the era of printing no knowledge could be spread rapidly among the mass of the people, and for the most part the counting of the ordinary man could be done upon his fingers.

A coin of Roger of Sicily is dated with the Hindu numerals in 1138. In 1390 an Italian coin is so dated; in France, one of 1485. There is a Scotch piece of 1538, but apparently none for England until 1551. A French manuscript of 1275 contains a treatise upon these numerals. They are used in the inscription upon a grave at Pforzheim in 1371, and upon one at Ulm in 1388. In 1470 they are used to date a book:*

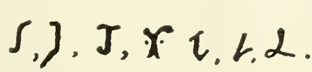
In 1471 the pages are so numbered in a work of Petrarch printed at Cologne.

They were still used in curious and confused combinations. In a work of 1470, 147 and 150 are written respectively*

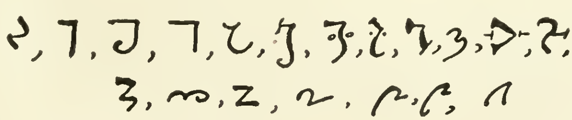
CC2 stands for 202. About the same time 12901 means 1291, m.cccc.8II stands for 1482, and MCCCCXL6 for 1446. Somewhat earlier c*a* is written for 104; somewhat later 1vojj for 1502.

The forms of the numeral signs varied as much as they do now upon the slates of children learning in school. These forms were not well fixed until after the general use of printing.

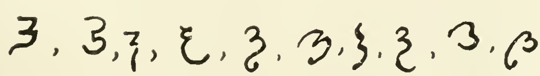
One is frequently written i. Other forms are*



Two is often z, so that iz = 12.*

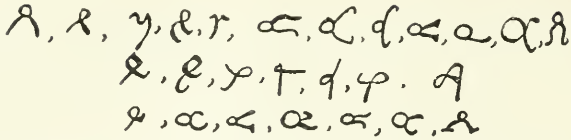


Three is usually recognizable.*

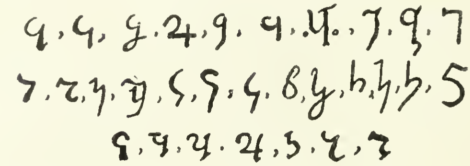


Not so four, which has varied greatly.*

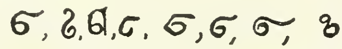
* From Smith and Karpinski, "The Hindu-Arabic Numerals."



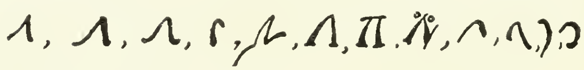
Five has changed a great deal, though it can usually be recognized.*



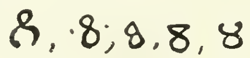
Six has changed but little.*



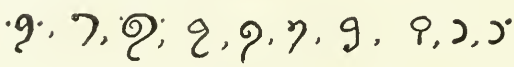
Up to the fifteenth century seven was usually recumbent in posture.*



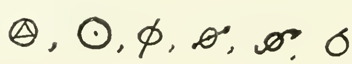
Eight has preserved its shape.*



So has nine for the most part.*



The symbol for nothing has varied greatly, and in an arbitrary manner.*



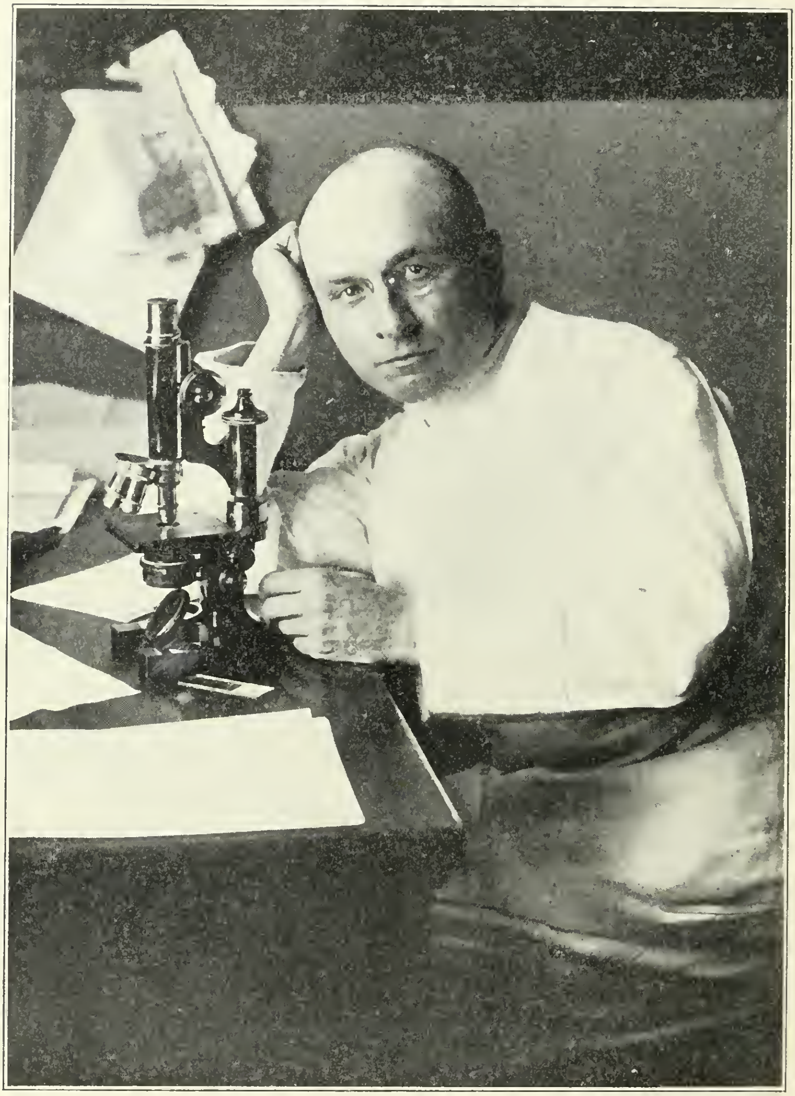
The name of this last symbol is interesting. The Hindus called it *sunya,* void. In Arabic this became *sifr* or *as-sifr.* In 1202 Leonardo Fibonacci translated it *zephirum;* in 1330 Maximus Planudes called it *τζίφρα*, *tziphra.* During the fourteenth century Italian writers shortened it to *zeucro* and *ceuro,* which became *zero,* now in general use. Meanwhile it had passed more nearly in Arabic form into French as *chiffre,* and into English as *cipher,* taking on new significations. Perhaps the schoolboy of to-day, who speaks of getting "zip" for an answer, is himself reverting to the Arabic.

After the Renaissance the Hindu numerals gradually supplanted other forms, and by the seventeenth century the process was nearly complete. From Europe in turn they have spread over the world, until they are now in general use wherever civilized man is living,

* From Smith and Karpinski, "The Hindu-Arabic Numerals."

except in some countries of the far east, near where they had their origin.

Such is the story of the numerals, and such is one phase of the development of the mind of man. In the childhood of the race we see him counting upon his lips, his fingers, or his toes. Then he assigns to his ideas symbols, and finally with prodigious difficulty gives to them a value of place. But when at last this has been done, and when he understands what he has done, his mind can travel upon the wings of light. In a twinkling he is able to make calculations which in physical terms express æons of time or stupendous distance along the pathway of the infinite. And all this he can do with ten little symbols, which can be written upon a shred of paper, or told off upon the fingers of his hands.



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Dr. Alexis Carrel,

Rockefeller Institute, New York City; recipient of the Nobel prize in medicine.

THE PROGRESS OF SCIENCE

THE AWARD OF THE NOBEL PRIZE IN MEDICINE

THE Nobel prize in medicine has this year been awarded to Dr. Alexis Carrel, of the Rockefeller Institute for Medical Research, New York City. This is an honor not only to the distinguished investigator, but also to the institution which has given him opportunity and to his adopted country. It may not be altogether satisfactory to our national pride that among some forty Nobel prizes conferred in the sciences only two have come to America, and that the men in both cases have been born abroad. Professor Michelson, who received the prize in physics, is, however, a graduate of the U. S. Naval Academy, and Dr. Carrel has done his work here. It is doubtless the case that obtaining a Nobel prize is a game in which to win skill and chance must be combined. We have native-born investigators who deserve as high honors as MM. Sabattier and Grignard, between whom the prize in chemistry has this year been divided, or Mr. Dalen, of the Stockholm gas works, to whom the prize in physics has been given. Still it should give us pause to reflect that no obvious injustice has been done by the failure to award a Nobel prize in medicine, physics or chemistry to a native American; perhaps also to consider that in the Rockefeller Institute, in addition to the director, Dr. Simon Flexner, of American birth but foreign parentage, and Dr. Carrel, there are at least three other foreign-born and foreign-educated investigators—Dr. Jacques Loeb, Dr. S. J. Meltzer and Dr. Hideyo Noguchi, to whom a Nobel prize might with justice be awared.

The work of Dr. Carrel is fairly well known, its character being such as to be comparatively interesting to the general public. He has extraordinary skill in technique, such as would give him a fortune beside which the $38,-000 of the Nobel prize would be small, if he were willing to be diverted from scientific research to surgical practise. His work also bears witness to imagination and patience, which when united to skill supply the essentials of successful investigation. It is easy to point out that Dr. Carrel has followed lines opened up by others; that organs had previously been transplanted and kept living outside the body; that Professor Harrison, of Yale University, anticipated him in the methods of cultivating living tissues; but this in no wise detracts from the importance of the work he has accomplished. As he himself said at the reception given to him at the College of the City of New York attended by President Taft and the French ambassador: "Almost every step in scientific progress which appears to be due to the efforts of one individual is, in reality, the result indirectly of the unknown scientific work of many others."

Dr. Carrel certainly is not responsible for the exaggerations of the newspapers. It is an excellent thing that the New York *Times* and other daily papers of New York City have become aware of the news value of the scientific work accomplished at the Rockefeller Institute. The reports are usually based on papers presented before scientific men and on articles printed in scientific journals; the investigator may suffer from headlines, inaccuracies and the exploitation of the sensational, but these may become eliminated, and the public may become

Dr. Simon Flexner,

Director of the Laboratories of the Rockefeller Institute, from a painting by Adèle Herter, of New York City, presented to the University of Pennsylvania by the colleagues and students of Dr. Flexner at the time he was professor there.

educated to the human interest of scientific research.

It may be regarded as a cause for congratulation that the administrators of the Nobel bequest have this year made some of the awards to younger men actively engaged in research—Dr. Carrel is not yet forty years old—rather than to men of distinction whose life work is practically complete, if only because this was the condition under which Nobel bequeathed his fortune. By his will it was specified that the prizes should be awarded to those persons who shall have contributed most materially to benefit mankind during the year immediately preceding; that no preference should be given to Scandinavians in the awards, and that the entire income should be used for five great prizes. The first condition may have been difficult to meet, but its spirit could have been followed, as has been done this year in the case of Dr. Carrel, by conferring the prize for work done recently, rather than for work done a generation ago, or as even this year in conferring the prize for literature on Dr. Hauptmann. It must still be regarded as unsatisfactory that a considerable part of the income has been used to establish Nobel Institutes at Stockholm, and it can scarcely be supposed that Dr. Gustrand, the Swedish oculist, would have received the award in medicine last year, or Mr. Dalen, the head of the Stockholm Gas Company, would have received it this year, had Nobel's intentions been fulfilled. It is ungracious to make criticisms when there is no reason to doubt that the administrators of the bequest are doing what they believe to be for the best advantage of science. At the same time, if no criticisms had been made, it is by no means certain that even more of the income might have been diverted to local uses, for in the statutes approved by the Swedish courts it was made possible to award the prizes only once in five years.

VITAL STATISTICS AND THE DECREASING DEATH RATE

The recently published seventy-third annual report of the registrar general of births, deaths and marriages in England and Wales gives an excellent summary of the vital statistics of England with convenient international comparisons. As is well known both birth rates and death rates have decreased in practically every nation in the course of the past thirty years. A comparison of the quinquennial period 1881–85 with 1910 for several countries gives the following rates per thousand population:

	Birth Rates 1881-5	Birth Rates 1910	Death Rates 1881-5	Death Rates 1910
England	33.5	25.1	19.4	13.5
Prussia	37.4	30.5	25.4	16.0
France	24.7	19.7	22.2	17.9
Italy	38.0	32.9	27.3	19.6
Russia	49.1	—	35.4	—
Australia	35.2	26.7	15.7	10.4
United States	unknown		unknown	

In this table "unknown" is written after the United States to emphasize our lack of vital statistics. Recent data from Russia are also lacking, but in that country and in the United States as elsewhere both birth rates and death rates have decreased in such a way as to leave a tolerably constant increment of population.

This correspondence, however, is by no means complete. Where both birth rates and death rates are high the increment of population tends to be larger than where they are low. This holds in general for nations, districts and social classes. The Slavonic nations, in spite of their waste of human life, are increasing more rapidly than others. The tenement house districts of New York City have a large infant mortality, but they swarm with children, whereas in the rich districts, there is less than a child to an apartment. The most striking instance on a large scale is France, with a birth rate some five lower and a death rate

some five higher than England, which has given to France a stationary, and last year a decreasing, population.

It is a question of fundamental importance whether the relation between the birth rate and the death rate will be maintained under existing conditions so as to give an increased or, at all events, a stationary, population. Will both continue to decrease, will they remain approximately as at present, or will the balance of the nineteenth century be lost as has apparently happened in France? The death rate has been halved by the practical abolition of war, pestilence and famine in their grosser forms, and by alleviation of their milder aspects—improved conditions for the struggling classes, the limitation and mitigation of disease, and better conditions of living. There is abundant room for further improvement, and it is stated by reputable authorities that the death rate can be halved again. But this is impossible; indeed, it seems that in certain nations the death rate has now reached its minimum. Australia and New Zealand now report a death rate of ten. This means that in a stationary population the average age at death is 100 years. For every infant that dies, a man must live to be 200 years old, or ten men live to be 110. This is almost beyond the limit of possibility. In 1910 the death rate in England and Wales was 13.5. This means in a stationary population an average age at death of 74 years, and as more than one seventh of all infants die, the average age of those surviving infancy would be about 85. The expectation of life of those 40 years old, which has not increased in the course of the last sixty years in spite of the lower death rate, is 28 years, so they die at the average age of 68 years.

The paradox is explained by the age constitution of the population. Owing to the high birth rate in England prior to 1876 and its subsequent decrease, an unusually large percentage of the population is from 5 to 40 years old, at which age the death rate is on the average only five per thousand. The population of England has about doubled by natural increase since 1850. Consequently old people more than sixty years old represent a population only half as great as children, and if a stationary population should hereafter be maintained, the percentage of old people would double. Indeed, as the death rate of children and of those under forty has decreased and will still further decrease, the percentage of old people will increase perhaps threefold. At present there are in France about as many people over sixty-five as there are children under five, while in England there are less than half as many, and in Russia with its high birth rate and death rate there are less than a third as many. The death rate of those over sixty-five is about 100; it has not decreased in the past sixty years, and is not likely to decrease considerably in the future. These old people now form about one thirtieth of the English population and contribute about three and a third units to its death rate; when they increase threefold, they will contribute ten units, and, if other conditions remain the same, the death rate will rise from 13.5 to 20. There will surely be a further decrease in the death rate of those under forty, but this will increase the number of those over forty, and will tend to increase their death rate. Probably a death rate of 15—an average age for those surviving infancy of from 75 to 80—is as low as will ever be permanently maintained by any nation. One may well wonder whether the birth rate will cease to decrease before or when it reaches the minimum death rate.

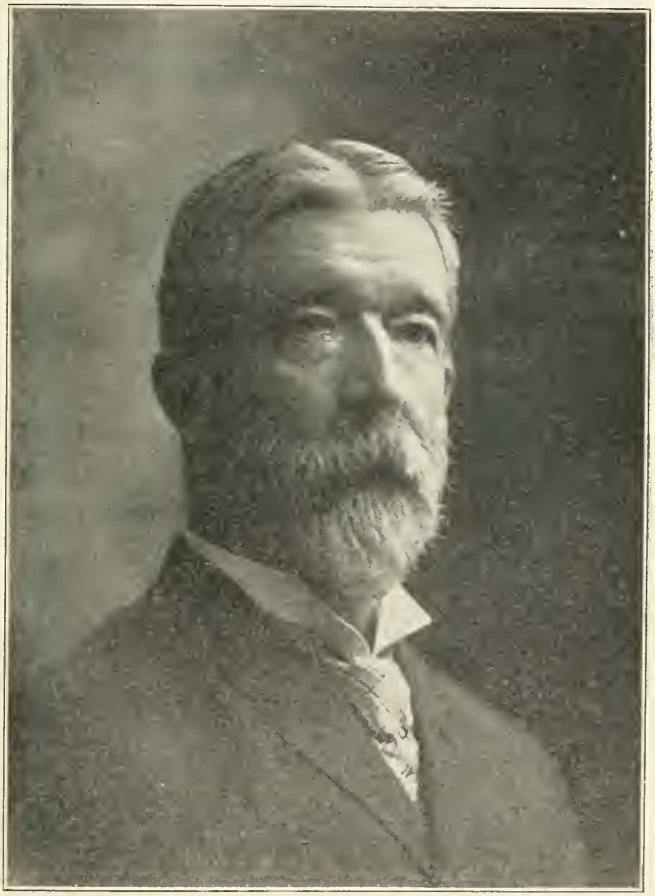
DR. LEWIS BOSS

THERE is no Nobel prize in astronomy, otherwise America would have had greater claims for the award than has been the case in medicine, physics and chemistry. It is a curious fact

that we have done better in sciences such as astronomy and zoology, having no immediate applications, than in medicine, physics and chemistry, where it might be supposed that the need of their applications and the wealth of the country would have led to researches in pure science. Perhaps the two greatest astronomers of the present generation have been Dr. G. W. Hill and the late Simon Newcomb. Another distinguished American astronomer, Lewis Boss, director of the Dudley Observatory at Albany, has died at the age of sixty-six years. His researches were technical in character, consisting largely of rigid determination of stellar positions. The catalogue in which he gives the positions and proper motions of 6,188 stars is a model of accurate work, and has led to discoveries of importance, such as the Taurus stream of stars. His work is highly appreciated by astronomers, and was given recognition by his appointment as director of the department of Meridian Astronomy of the Carnegie Institution. Science suffers severely in his death.

SCIENTIFIC ITEMS

WE record with regret the death of Dr. John William Mallett, F.R.S., pro-



DR. LEWIS BOSS.
late director of the Dudley Observatory.

fessor emeritus of chemistry at the University of Virginia and eminent for his contributions to chemistry; of Dr. John Monroe Van Vleck, professor of mathematics at Wesleyan University from 1853 until his retirement as emeritus professor in 1904, and of Major General Robert Maitland O'Reilly, U.S.A., retired, former surgeon general of the United States Army.

Dr. Andrew D. White, the first president of Cornell University, distinguished for his work in education and diplomacy, and for his publications on history and science, celebrated his eightieth birthday on November 7.—Dr. Edward W. Morley, the American chemist, has been made an honorary member of the Swiss Association for the Advancement of Science.—The gold medal for science of the Prussian government has been conferred on Dr. Robert Helmert, director of the Geodetic Institute of Potsdam.

The American Association for the Advancement of Science and the national scientific societies affiliated with it will hold their convocation week meeting at Cleveland, Ohio, beginning on Monday, December 30. Cleveland is centrally situated between the Atlantic seaboard and the scientific centers of the central states, and Western Reserve University, the Case School of Applied Science, and the other scientific institutions of the city will supply excellent places of meeting. The address of the retiring president is made by Dr. C. E. Bessey, of the University of Nebraska, while Dr. E. C. Pickering, director of the Harvard College Observatory, will preside over the meeting. A large number of important and interesting addresses are assured from the vice-presidents of the association, the presidents of the affiliated societies and others who will take part in the scientific proceedings. There is sure to be a large attendance of scientific men. In recent years, however, the American Association has fallen behind the British Association in its influence on the general public and in the number of those not professionally engaged in scientific work who are attracted to its meetings. Those who are interested in such a meeting and might like to become members of the association should write to the permanent secretary, Dr. L. O. Howard, Smithsonian Institution, Washington, D. C.

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